UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ARKEMA FRANCE,

Petitioner,

v.

HONEYWELL INTERNATIONAL, INC.,

Patent Owner.

IPR No. IPR2015-00916

U.S. Patent No. 8,710,282

DECLARATION OF LEO E. MANZER, PH.D.

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I, Leo E. Manzer, do hereby declare as follows:

I. Overview

1. I am over the age of eighteen (18) and otherwise competent to make this Declaration. I have been retained by Arkema France ("Arkema") in connection with the above-captioned petition for *inter partes review* (IPR). I am being compensated for my time in connection with this matter at an hourly rate of $400 per hour. My compensation is in no way dependent upon the outcome of the IPR. I am not an employee of Arkema or any affiliate or subsidiary thereof.

2. I understand that the petition for IPR involves U.S. Patent No. 8,710,282 ("the '282 patent"), which resulted from U.S. Application No. 13/229,016, filed on September 9, 2011, and claims priority to U.S. Provisional Application No. 61/392,242 filed October 12, 2010. I also understand that my testimony will be submitted for the IPR to be considered before the Patent Trial and Appeal Board ("PTAB").

3. I have been asked to provide my opinions relating to the validity of the '282 patent. In this Declaration, I provide opinions relating to claims 1-46 of the '282 patent. Specifically, and as explained herein, it is my opinion that claims 1-46 are obvious in view of the prior art. As described herein, the disclosures of the prior art set forth the claim elements in a sufficiently detailed manner such that a person of ordinary skill in the art ("POSITA") (*i.e.*, a person of ordinary skill in the field

of hydrofluorocarbon synthesis) would have been motivated to combine and/or modify the prior art teachings in the manner claimed and would have had a reasonable expectation of success in doing so.

4. In preparing this Declaration, I have reviewed the '282 patent, and considered each of the documents cited herein, in light of my general knowledge as a process chemist over the past 35 years. In formulating my opinions, I have relied upon my experience and I have also considered the viewpoint of a POSITA on or around October 12, 2010.

5. The opinions expressed in this Declaration are not exhaustive of my opinions on the validity of claims 1-46 of the '282 patent. Therefore, the fact that I do not address a particular point should not be understood to indicate any agreement on my part that any claim otherwise complies with requirements for patentability or is valid.

II. My Background and Qualifications

6. I am an expert in the field of the manufacture of hydrofluorocarbons based on my experience at E.I. du Pont de Nemours and Company ("DuPont") and related consulting work. I have been an expert in this field since prior to 2010. Throughout the remainder of this Declaration, I will refer to the field of the manufacture of hydrofluorocarbons as the relevant field or the relevant art. In formulating my opinions, I have relied upon my training, knowledge, and

experience in the relevant art. A copy of my current curriculum vitae is provided as Exhibit A of this Declaration, and it provides a comprehensive description of my academic and employment history.

7. As an expert in this field since prior to 2010, I am qualified to provide an opinion as to what a POSITA would have understood, known or concluded as of 2010. Since 1986, I have accumulated significant training and experience in this and related fields.

8. I received a B.S. in Chemistry from the University of Waterloo, Ontario, Canada in 1970.

9. I received a Ph.D. in Chemistry from Western University, Ontario, Canada in 1973.

10. After completing my Ph.D., I joined DuPont as an organometallic chemist working on synthesis and homogeneous catalysts. One of my largest projects at DuPont involved the manufacture of chlorofluorocarbon (CFC) alternatives. DuPont was the world's largest producer of CFCs in 1986 when science linked CFCs to the depletion of stratospheric ozone and the formation of the Antarctic ozone hole. DuPont management immediately committed to phasing out CFCs in an orderly fashion, and to developing environmentally safer alternatives such as hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs) as quickly as possible. I led the R&D effort to develop manufacturing routes to these new

products. The technology used to manufacture CFC alternatives was very diverse, using gas and liquid phase reactors, and involving hazardous chemicals such as HF and chlorine. DuPont was recognized in 2002 for this effort by the Presidential Medal of Technology Award. I was one of three scientists recognized for this large effort.

11. Many of my other projects at DuPont also involved bulk chemical manufacturing. For example, in 1990 I initiated a large program to develop lower cost processes for the bulk production of tetrafluoroethylene (TFE) and hexafluoropropylene (HFP). In 1998, I initiated a program directed to the conversion of natural gas to liquid fuel. Beginning in 2000, I led an effort to identify platform molecules and develop processes for the conversion of biomass feedstocks to bulk fuels and chemicals. I retired from DuPont in 2005 as one of only 15 DuPont Fellows out of the company's 5000 scientists and engineers.

12. Following my retirement from DuPont, I have remained active in consulting in the areas of catalysis and process development. In 2005, I founded Catalytic Insights, LLC, and have provided consultancy in the areas of catalysis and chemical process development.

13. Throughout my professional career, both at DuPont and as an independent consultant, I have been active in the area of bulk chemical manufacturing, including hydrofluorocarbon manufacturing. I am a named inventor on 158 U.S.

patents, primarily in the area of bulk chemical manufacturing, including 28 patents relating to chlorofluorocarbon replacements. For example, I am a named inventor on multiple patents related to hydrofluorocarbon manufacturing, including U.S. Patent No. 6,762,333, "Process for Reducing the Fluorine Content of Hydrocarbons and Hydrofluorocarbons" (2004); U.S. Patent No. 6,624,337, "Process for the Manufacture of Fluoroolefins" (2003); U.S. Patent No. 6,281,396, "Fluorocarbon purification process" (2001); U.S. Patent No. 5,345,016, "Manufacture of 1,1,1,2-tetrafluoroethane" (1994); U.S. Patent No. 4,935,558, "Reductive Dechlorination of 1,1,1,2-tetrafluoro-2-chloroethane" (1990); and U.S. Patent No. 4,902,838, "Isomerization of Saturated Fluorohydrocarbons" (1990). I also am a named inventor on numerous other patents related to bulk chemical manufacturing, including U.S. Patent No. 8,748,638, "Processes for Preparing Diacids, Dialdehydes and Polymers" (2014); U.S. Patent No. 8,507,718, "Ketocarboxylic Acids, Methods of Manufacture and Uses Thereof" (2013); U.S. 8,466,300, "Processes for the Production of Hydrogenated Products" (2013); U.S. Patent No. 8,129,550, "Oxidation of 5-(Hydroxymethyl)furfural to 2,5 Diformylfuran and Subsequent Decarbonylation to Unsubstituted Furan" (2012); and U.S. Patent No. 7,067,708, "Process for the Preparation of p-Xylene" (2006).

14. I have co-authored over 90 publications, including 13 relating to chlorofluorocarbon replacements. I have published extensively in the area of

hydrofluorocarbon and hydrochlorofluorocarbon manufacturing. *See, e.g.*, Zarah Ainbinder, Leo E. Manzer & Mario J. Nappa, *Catalytic routes to hydro(chloro)fluorocarbons*, *in* Handbook of Heterogeneous Catalysis 2426-2434 (2nd ed. 2008); L. E. Manzer, Z. Ainbinder & M. Nappa, *CFC Alternatives*, *in* Handbook on Heterogeneous Catalysis (G. Ertl et al. eds. 1997); L.E. Manzer & V.N.M. Rao, *Recent Advances in the Synthesis of Chlorofluorocarbon Alternatives*, 39 Advances in Catalysis 329-350 (1993).

15. I have also presented or co-presented at national, international and regional scientific meetings regarding various aspects of hydrofluorocarbon synthesis. For example, I presented "Heterogenous Catalytic Hydrogenation of Chlorofluorocarbons" for the Presidential Green Chemistry Symposium in 1997, "Catalytic Synthesis of Fluorocarbons: Past Present and Future" at the 17th North American Catalysis Society Meeting in 2001, and "An Overview of the Commercial Development of Chlorofluorocarbon (CFC) Replacements" at the Green Workshop in 2002. Furthermore, as listed in my *curriculum vitae*, I have been a member of numerous advisory boards relating to chemical engineering and hydrofluorocarbon synthesis including: the Center for Catalytic Science and Technology at the University of Delaware, Environmentally Conscious Chemical Manufacturing Center at the University of Virginia, Department of Chemistry at Vanderbilt University, Department of Chemical Engineering at Tulane University,

Catalysis Advisory Board at Los Alamos National Laboratory, Stacie Institute for Molecular Sciences for the National Research Council of Canada, Center for Catalysis Research and Innovation at the University of Ottawa. I have also served as an adjunct professor for the department of chemical engineering at the University of Delaware.

16. In addition to gaining expertise via my educational training, professional experiences, and research experiences described above, I have kept abreast of the field by reading scientific literature, attending or presenting at scientific conferences, and attending or presenting at academic symposia. In addition to writing and publishing numerous scientific articles as listed in my current *curriculum vitae*, I have been invited to participate in the peer review process for various scientific journals. In this capacity, I have reviewed manuscripts relating to chemical engineering and hydrofluorocarbon synthesis. Some of the scientific journals for which I have reviewed scientific manuscripts as a member of the editorial board include: *Catalysis Review, Catalysis Today, Applied Catalysis A: General, Industrial Catalysis News, Clean Products and Processes, Chemistry for Sustainable Development, C&E News, and Journal of Catalysis*. Furthermore, I have collaborated with or have communicated with many of the researchers in the field of hydrofluorocarbon synthesis. Accordingly, I am an expert in the field of hydrofluorocarbon synthesis.

17. As an expert in the relevant field, I am qualified to provide an opinion as to what a POSITA would have understood, known, or concluded as of 2010.

III. Legal Standards for Patentability

18. I am a technical expert, and do not offer any legal opinions. However, I applied the below legal standards in developing my technical opinions expressed in this Declaration.

A. Person of Ordinary Skill in the Art

19. I understand that the person of ordinary skill in the art, which is relevant to claim construction, and other analysis related to forming my opinion, is a hypothetical person skilled in the art, who is not a judge, nor a layperson, nor one skilled in the remote arts, nor a genius in the art at hand. This person of ordinary skill is an individual who is presumed to be one who thinks along the lines of conventional wisdom in the art and is not one who undertakes to innovate, whether by extraordinary insight or systematic research. The person of ordinary skill is also a person of ordinary creativity, not an automaton.

20. Relevant factors in determining the level of ordinary skill in the art include the educational level of the inventors and those who work in the field. Other considerations include various prior art approaches employed in the art, types of problems encountered in the art, the rapidity with which innovations are made, and

the sophistication of the technology involved. Not all considerations may be present in every case, and the education level of inventors is not itself conclusive.

B. Claim Construction

21. I understand the first step in determining whether or not a patent claim is valid is to properly construe the claims. I have considered and applied Arkema's proposed claim constructions in my analysis in this Declaration. I reserve my right to amend or alter my analysis and opinions in view of the Patent Owner's proposed claim constructions, if any.

22. I also understand that the claims must be given their broadest reasonable interpretation in view of the patent specification as it would be read by a POSITA. I also understand that the claims must be supported by the specification. Also, to the extent that a patent claims priority to an earlier filed application, the claims must be supported by the disclosure in that application.

C. Date of Invention

23. I understand that absent clear and convincing evidence of invention date prior to the filing date of a patent, the invention date of the patent is presumed to be its filing date. A prior invention requires a complete conception of the invention and a reduction to practice of that invention. The patentee has the burden of establishing by clear and convincing evidence a date of conception earlier than the filing date of the patent.

24. Conception is the formation in the mind of the inventor of a definite and permanent idea of the complete and operative invention. Conception must be proved by corroborating evidence that shows the inventor disclosed to others his complete thought expressed in such clear terms as to enable those skilled in the art to make the claimed invention. The inventor must also show possession of every feature recited in the claims, and that every limitation was known to the inventor at the time of the alleged conception. Furthermore, the patentee must show that he or she has exercised reasonable diligence in later reducing the invention to practice, either actual or constructive. The filing of a patent application can serve as a constructive reduction to practice.

D. Priority Claim

25. I understand that a U.S. application is entitled to the benefit of the filing date of an earlier filed U.S. application if the subject matter of the claim is disclosed in the manner provided by 35 U.S.C. § 112, first paragraph, in the earlier filed application. I understand that 35 U.S.C. § 112, first paragraph, includes three separate requirements: written description, enablement, and best mode.

26. I understand that the relevant inquiry for existence of sufficient written description is whether a patent sets forth enough detail to allow a person skilled in the relevant art to understand what is being claimed and to reasonably conclude that the inventor had possession of the claimed invention.

E. Obviousness

27. I understand that a patent claim is invalid if the subject matter of the claim as a whole would have been obvious to a person having ordinary skill in the art of the claimed subject matter as of the time of the invention at issue.

28. Unlike a determination of anticipation, which allows consideration of only one item of prior art, I understand that obviousness may be shown by considering more than one item of prior art.

29. In addition, I understand that the obviousness inquiry should not be done in hindsight, but must be done using the perspective of a POSITA as of the effective filing date of the patent claim.

30. I understand that an invention is obvious if a POSITA would have seen an obvious benefit to the solutions tried by the applicant. If a technique has been used to improve one device or system, and a POSITA would recognize that it would improve similar devices or systems in the same way, using the technique would have been obvious. For example, I understand that a claimed invention may be obvious if some teaching, suggestion, or motivation that would have led a POSITA to combine the invalidating references exists. I also understand that obviousness may be shown by demonstrating that it would have been obvious to modify what is taught in prior art to create the patented invention.

31. I understand that to find a claim in a patent obvious, one must make certain findings regarding the claimed invention and the prior art. Specifically, I understand that the following factors must be evaluated to determine whether the claimed subject matter is obvious: (1) the scope and content of the prior art; (2) the difference or differences, if any, between each claim of the patent and the prior art; (3) the level of ordinary skill in the art at the time the patent was filed; and (4) any so-called objective indicia of non-obviousness.

32. I have been informed and I understand that so-called objective indicia of non-obviousness, also known as "secondary considerations," include: (1) commercial success; (2) long-felt but unresolved needs; (3) copying of the invention by others in the field; (4) initial expressions of disbelief by experts in the field; (5) failure of others to solve the problem that the inventor solved; and (6) unexpected results. I also understand that evidence of objective indicia of non-obviousness must be commensurate in scope with the claimed subject matter.

33. I also understand that market demands or design considerations may prompt variations of a prior art system or process, either in the same field or a different one, and that these variations or "design choices" will ordinarily be considered obvious variations of what has been described in the prior art.

IV. List of Documents Considered in Formulating My Opinions

34. In formulating my opinion, I have considered the following documents:

Exhibit No.	Document	Abbreviation
Ex. 1001	U.S. Patent No. 8,710,282	'282 patent
Ex. 1003	International Publication No. WO 2009/138764 A1	*Smith*
Ex. 1004	Japanese Publication No. JP S59-70626	*Masayuki*
Ex. 1005	English language translation of Japanese Publication No. JP S59-70626	*Masayuki*
Ex. 1006	U.S. Patent No. 4,414,185	*Harrison*
Ex. 1008	L. Knunyants et al., *Reactions of Fluoro Olefins*, 9 Bulletin of the Academy of Sciences of the USSR 1312 (1960)	*Knunyants*
Ex. 1009	U.S. Publication No. 2009/0278075 A1	*Mahler*
Ex. 1010	International Publication No. WO 2007/056194 A1	*Mukhopadhyay*
Ex. 1011	U.S. Provisional Application No. 61/392,242	'242 provisional
Ex. 1012	U.S. Provisional Application No. 61/036,526	'526 provisional
Ex. 1013	U.S. Patent Application No. 12/402,372	'372 non-provisional
Ex. 1014	U.S. Patent Application No. 13/195,429	'429 non-provisional
Ex. 1016	J. M. Douglas, *Conceptual Design of Chemical Processes* (1988)	*Douglas*

V. Relevant Field of Art

35. I have been asked for the purposes of this Declaration to opine on the level of knowledge and understanding of one of ordinary skill in the relevant field of art as of no later than October 12, 2010, the earliest effective priority date of the '282 patent.

36. Based on my review of the '282 patent, the relevant field of art relates to bulk chemical synthesis and manufacturing, including production of fluorinated olefins by dehydrohalogenation of fluorinated alkanes.

VI. Person of Ordinary Skill in the Art (POSITA)

37. I understand that a POSITA is one who is presumed to be aware of all pertinent art, thinks along conventional wisdom in the art, and is a person of ordinary creativity. A POSITA would have knowledge of the scientific literature concerning hydrofluorocarbon synthesis as of 2010. A POSITA is a person: (1) having a Ph.D. in chemistry, chemical engineering, or a closely related discipline with at least 2 years of practical experience in hydrofluorocarbon synthesis or (2) a B.S. in chemistry, chemical engineering, or a closely related discipline with at least 5 years of practical experience in hydrofluorocarbon synthesis. A person having this level of schooling and experience is knowledgeable about and experienced with chemical process design and operation, including optimization and problem solving related to sub-optimal process performance. Such person would understand basic and advanced concepts of chemical process design and operation and would have experience implementing such concepts in an operational setting. Such person would understand the references cited herein and would have the capability to draw inferences from them.

VII. The '282 Patent

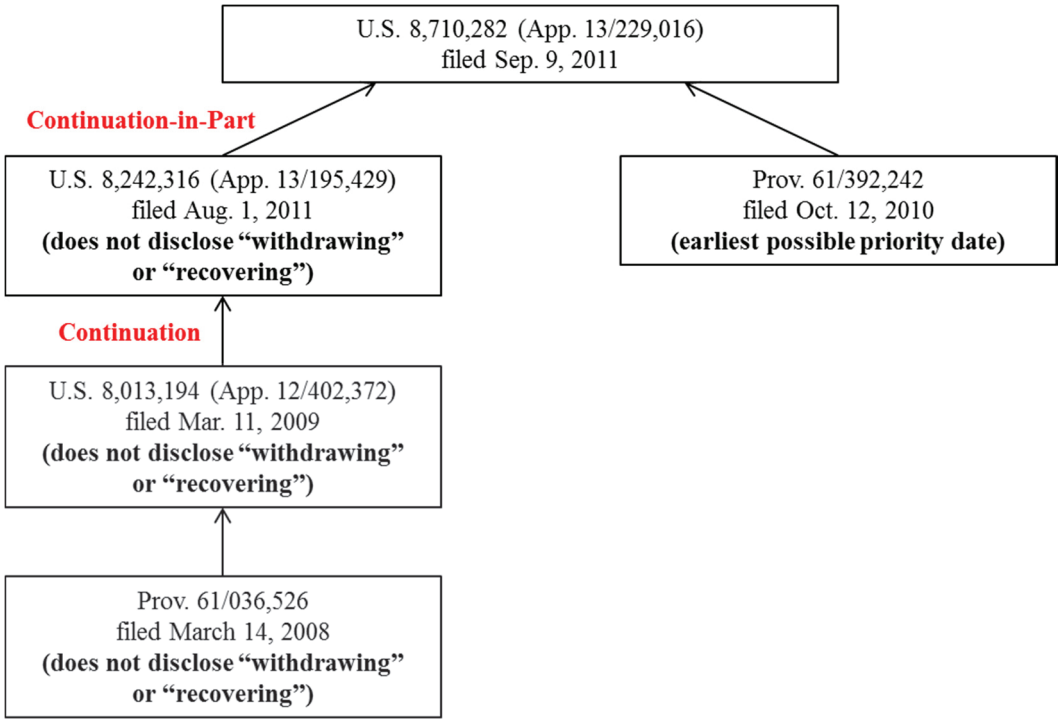
38. I understand that this Declaration is being submitted together with a petition for *inter partes* review of the '282 patent (Ex. 1001).

39. I have considered the disclosure of the '282 patent in light of general

knowledge in the art as of the earliest possible priority date of the '282 patent, which I understand to be October 12, 2010 (see below).

40. In general, the process described in the '282 patent includes the following steps: (a) hydrogenating a first haloolefin to produce a haloalkane; (b) optionally separating said haloalkane into a plurality of intermediate product streams comprising two or more streams selected from the group consisting of a first stream rich in at least a first alkane, a second stream rich in a second alkane and an alkane recycle stream; (c) dehydrohalogenating the haloalkane in (a) or (b) in the presence of a dehydrohalogenating agent [hereinafter "DHA"] to produce a second haloolefin; (d) withdrawing a reaction stream comprising spent DHA and, optionally, metal fluoride salt by products; and (e) recovering, purifying and/or regenerating spent DHA. Ex. 1001 at 3:4-17. I note that step (b) is optional and is not required by any of the claims of the '282 patent.

41. I understand the '282 patent is related to several prior applications as shown below:



42. I have reviewed all of the applications set forth in the diagram above. None of the '526 provisional, the '372 non-provisional, or the '429 non-provisional applications explicitly or implicitly disclose, support, or enable "withdrawing" spent DHA or KOH or "recovering" spent DHA or KOH as required in claims 1, 10, 21, and 36.

43. A brief explanation of the differences between the various types of dehydrohalogenation reactions explains why the '526 provisional, '372 non-provisional, and '429 non-provisional applications do not explicitly or implicitly disclose, support, or enable "withdrawing" spent DHA or KOH or "recovering" spent DHA or KOH. The background section of the '282 patent describes two types of processes for performing dehydrohalogenation: (1) DHA-mediated

dehydrohalogenation and (2) gas phase catalytic dehydrohalogenation. A dehydrohalogenating process using DHA, such as that claimed in the '282 patent, generally is a liquid phase process where a haloalkane is reacted with a basic DHA (e.g., KOH) to produce a haloalkene (or olefin) and by-products, such as salts (e.g., KF). In contrast, a gas phase catalytic dehydrohalogenation process involves the use of a solid dehydrohalogenation catalyst rather than a DHA. The '526 provisional, the '372 non-provisional, and the '429 non-provisional applications are directed to catalytic gas phase dehydrohalogenation in the presence of a solid catalyst, rather than to DHA-mediated dehydrohalogenation.[1] Thus, the '526 provisional, the '372 non-provisional, and the '429 non-provisional applications do not teach anything with respect to withdrawing and recovering spent DHA or KOH since they are directed to gas phase catalytic dehydrohalogenation rather than DHA-mediated dehydrohalogenation. Moreover, a POSITA would not understand these applications to require withdrawing or recovering DHA or KOH. In my

[1] It is noted that these applications contain the statement, "…it is contemplated that the dehydrohalogenation step may comprise, in certain nonpreferred embodiments, a liquid phase reaction." However, there is no explicit or implicit disclosure, support, or enablement for using a DHA or KOH or for withdrawing or recovering DHA or KOH.

opinion, based on the disclosure of the '526 provisional, the '372 non-provisional, and the '429 non-provisional applications, a person of ordinary skill in the art would not conclude that the inventors of these applications had possession of the subject matter of claims 1-46 of the '282 patent at the time of filing these applications. Therefore, I understand that the earliest possible priority date of the '282 patent is October 12, 2010.

44. A person of ordinary skill in the art would understand the terms below as follows:

Term	Meaning
"spent DHA" or "spent KOH"	"unreacted [DHA or KOH] remaining after the dehydrohalogenation reaction"
"withdrawing"	"taking out or removing"
"recovering spent DHA" or "recovering spent KOH"	"collecting spent [DHA or KOH] for further use (may include separating, purifying, concentrating, and/or regenerating)"
"recycling"	"returning a component of the process to the process"
"dehydrofluorinated product stream" or "product stream"	"a volume of material resulting from dehydrofluorination including dehydrofluorinated organic product(s)"
"product reaction stream", "second product stream", or "reaction stream"	"a volume of material including spent DHA that may also contain by-product

	salts and dissolved organics"
"dissolved organics"	"organic that is dissolved in a stream"

45. In general, a POSITA would understand the term "spent" to mean that some sort of processing step has taken place related to the component that is referred to as being spent. Examples of the dehydrohalogenation reactions described in the '282 patent are described by the following reaction equations (1) and (2):

$$CF_3—CHF—CHF_2+KOH \rightarrow CF_3CF{=}CHF+KF+H_2O \quad (1)$$

$$CF_3—CHF—CH_2F+KOH \rightarrow CF_3CF{=}CH_2+KF+H_2O \quad (2)$$

Ex. 1001 at 12:26-29. In the general context of dehydrohalogenation reactions, spent DHA (or KOH) could mean DHA (or KOH) that has been converted to a by-product salt (such as KF) through reaction. Spent DHA (or KOH) could also mean unreacted DHA (or KOH) that was present in the reactor during dehydrofluorination but was unreacted. The term "spent" indicates that the unreacted DHA (or KOH) may have been contaminated in some way because it was present in the dehydrofluorination reactor during the reaction and is thus in the presence of other reagents, products, and by-products after the reaction. The presence of a by-product salt indicates that a dehydrofluorination reaction took place and that the "spent" DHA (or KOH) was in the reactor during dehydrofluorination but was unreacted during the process.

46. After reviewing the specification of the '282 patent, a POSITA would understand that spent DHA (or KOH) does not refer to DHA (or KOH) that has been converted to a by-product salt (e.g., KF) because the patent distinguishes between "spent DHA" and "by-product salts." For example, the '282 patent states: "…(d) withdrawing a reaction stream comprising spent [DHA] and, optionally, metal fluoride salt by products…" *Id*. at 3:13-15. In the "Dehydrohalogenation" section of the '282 patent starting at 12:11, spent DHA and by-product salts are referred to as two separate components: "[s]pent [DHA] and by-product salts (e.g., metal fluoride salts) may be withdrawn from the reactor by a product stream either continuously or intermittently using one or more separation techniques". *See, e.g.*, *id.* at 13:16-19. After reading the specification, a POSITA would understand that the term spent DHA (or KOH) relates to DHA (or KOH) in its unconverted form and would understand spent DHA (or KOH) to mean DHA (or KOH) remaining after the dehydrohalogenation reaction.

47. The term "withdrawing" means "taking out or removing". The process described in the '282 patent includes "[r]emoval of spent [DHA] from the reactor…" *Id*. at 2:61-63. The '282 patent further states that "[r]emoval of spent [DHA] from the reactor reduces design and operation costs and recycling the spent and/or regenerated [DHA] leads to improved efficiency." *Id*. at 6:18-21. The '282 patent further states "[i]n certain embodiments, spent [DHA] is removed from the

product stream either periodically or continuously and is recycled back to the reactor for reuse." *Id*. at 13:3-5.

48. The examples in the specification describe taking KOH out of the dehydrohalogenation reactor. In Examples 1 and 2, spent KOH is removed from the product stream: "Organic out (the overhead portion) was constantly taken out [of the reactor]" and "valves for the spent KOH to go out [of the reactor] were open". *Id*. at 15:30-31, 36, 58-59. In Example 3, spent KOH is also withdrawn from the product stream: "Spent KOH was taken out of reactor periodically (it was fed continuously as was organic; overhead product was taken out continuously, i.e. semicontinuous operation)." *Id*. at 16:6-8.

49. The "withdrawing" steps of claims 1 and 10 are phrased differently than the withdrawing steps of claims 21 and 36, which simply state "withdrawing a reaction stream comprising spent KOH." For example, claim 1 specifies "withdrawing *from a dehydrofluorinated product stream* a product reaction stream comprising spent [DHA]." Similarly, claim 10 recites "withdrawing *from the product stream* a second product stream comprising spent [DHA]." A POSITA would not understand these claims to require the spent DHA to be *part of* the gaseous (dehydrofluorinated) product stream from which it is withdrawn because such an understanding would be inconsistent with how a POSITA would expect materials of different phases (solid, liquid, gas) to interact with one another under the

operating conditions described in the '282 patent and would also be inconsistent with the examples in the specification. Example 1 of the '282 patent states that "[o]rganic out (the overhead portion) [i.e., the (dehydrofluorinated) product stream] was constantly taken out" while "…applicable valves for the spent KOH [i.e., the product reaction stream/second product stream comprising spent KOH] to go out were open." Ex. 1001 at 15:30-36. Similarly, Example 3 states "[S]pent KOH was taken out of reactor periodically…" Ex. 1001 at 16:6. Consistent with these passages, a POSITA would understand the "withdrawing" limitations of claims 1 and 10 to encompass "taking out or removing" a stream comprising spent DHA from a reactor containing a separate product stream that includes dehydrofluorinated product.

50. In general, it is desirable to "recover" valuable reactants. The '282 patent uses the terms "recovering spent DHA" in claims 1 and 10 and "recovering spent KOH" in claims 21 and 36. "Recovering" in the context of the '282 patent means "collecting spent DHA or KOH, respectively, for further use and may include separating, purifying, concentrating and/or regenerating". The '282 patent describes "the invention" as relating "…to a method of increasing the cost efficiency for dehydrohalogenation production of a fluorinated olefin by recovering and recycling spent reagent" as well as "(d) recovering, purifying and/or regenerating spent [DHA]." *Id.* at 2:49-52, 3:15-17. The

"Dehydrohalogenation" section of the '282 patent includes the following paragraph describing withdrawing and recovering:

> The product stream containing spent dehydrohalogenating agent typically carries with it some dissolved organic (e.g. HFC-236ea and/or HFC-245eb). By stopping the stirrer and then removing [i.e., "withdrawing"] spent dehydrohalogenating agent [from the dehydrohalogenation reactor] during the time agitation is stopped, separation of dehydrohalogenating agent and such organic can be facilitated. Spent dehydrohalogenating agent and dissolved organic would be taken into a container where additional separation of dehydrohalogenating agent and organic can be accomplished using one or more of the foregoing separation techniques [i.e., "recovering"]. In one non-limiting embodiment, for example, KOH is separation [sic] by distillation, i.e. by heating organic just above boiling point of 236ea and/or 245eb, thus fractionating the organic from the spent KOH. Alternatively, one can use phase separator [sic] to separate between the two phases. The organic free KOH isolate can be immediately recycled to the reactor or can be concentrated and the concentrated solution can be returned to reactor.

Id. at 13:29-45 (parentheticals added). The Examples of the '282 patent also describe using a Scrubber Product Collection Cylinder (SPCC) "…to collect spent KOH and the portion of organic that was carried out with spent KOH." *Id*. at 15:44-46. The term "recovered" is also used in connection with the recovery of HFO-1234yf: "This HFO-1234yf is then separated from the final product stream

and recovered as a purified product." *Id*. at 4:52-53.

51. The term "recycling" means "returning a component of the process to the process". The '282 patent uses the term recycling in a manner consistent with its generally understood meaning: "The organic free KOH isolate can be immediately recycled to the reactor or can be concentrated and the concentrated solution can be returned to reactor." Ex. 1001 at 13:43-45.

52. "Dehydrofluorinated product stream" (claim 1) and "product stream" (claim 10) mean "a volume of material resulting from dehydrofluorination including dehydrofluorinated organic product(s)." Thus, if the dehydrofluorination reaction was intended to produce 1234yf, the dehydrofluorinated product stream would be a volume of fluid that contains 1234yf. If the desired olefin product was 1225ye, the dehydrofluorinated product stream would be a volume of fluid that contains 1225ye. In Example 1, an exemplary dehydrofluorinated product stream is the organic product (overhead) that was constantly taken out. The specification of the '282 patent explains that "the resulting product stream formed [in the dehydrohalogenation reaction] would be fed into a condenser or distillation column for separation of 1225ye and/or 1234yf from … un-reacted 236ea and/or 245eb, as well as other by-products of the reaction." *Id*. at 12:66-13:3 (parentheticals added).

53. The terms "product reaction stream" (claim 1), "second product stream" (claim 10), and "reaction stream" (claims 21 and 36) mean "a volume of material

present after dehydrofluorination including spent DHA that may also contain by-product salts and/or dissolved organics." Claim 1 refers to the "product reaction stream" as "comprising spent [DHA]" in paragraph d. Claim 10 also refers to the "second product stream" as "comprising spent [DHA]" in paragraph c. Claims 21 and 36 refer to the "reaction stream" as "comprising spent KOH."

54. The "product reaction stream", "second product stream", and "reaction stream" can include dissolved organics and by-product salts. Claims 11, 28, and 39 recite that the "second product stream" or the "reaction stream" further comprises dissolved organics. Claim 16 states that the reaction stream further comprises by-product salts of the [DHA]. Claims 33 and 44 recite that the "the reaction stream further comprises KF". The specification states that "[s]pent [DHA] and by-product salts (e.g., metal fluoride salts) may be withdrawn from the reactor by a product stream either continuously or intermittently using one or more known separation techniques." *Id.* at 13:16-19. Moreover, the Examples include separating dissolved organics from spent KOH. Further, in Example 1, an exemplary product reaction stream includes the spent KOH that was taken out of the dehydrofluorination reactor every 40 minutes. *Id.* at 15:35-37. As POSITA would understand, the spent KOH was being taken out in the aqueous phase along with KF and dissolved organic. Accordingly, the terms "product reaction stream", "second product stream", and "reaction stream" should be construed as "a volume

of material including spent DHA that may also contain by-product salts and/or dissolved organics."

55. The term "dissolved organics" means "organic that is dissolved in a stream". The term "dissolved organics" is not defined in the '282 patent. The specification states that "[t]he product stream containing spent [DHA] typically carries with it some dissolved organic (e.g. HFC-236ea and/or HFC-245eb)". Ex. 1001 at 13:29-31. Claims 11, 28 and 39 specify that the second product stream or reaction stream further comprises dissolved organics. Claims 12, 29, and 40 indicate that the dissolved organics may be 236ea or 245eb. The ordinary meaning of the term "dissolved" means that the dissolved organic is in solution with at least a portion of the stream.

VIII. Synonym and Formula Table

56. The following table includes conventional names and synonyms for the hydrofluorocarbons, as well as formulas, referenced in the '282 patent:

Conventional Name	**Chemical Formula**	**Synonym**	**Formula**	**Variables**
1,1,2,3,3,3-hexafluoropropene	$CF_3CF=CF_2$	HFP	Claim 1 Formula (I): $(CX_nY_{3-n})(CR^1_aR^2_b)_zCX=CH_mX_{2-m}$	*X = F* *n = 3* *z=0* *m=0*
1,2,3,3,3-pentafluoropropene	$CF_3CF=CHF$	1225ye	Claim 1 Formula (I): $(CX_nY_{3-n})(CR^1_aR^2_b)_zCX=CH_mX_{2-m}$	*X = F* *n = 3* *z = 0* *m = 1*
1,1,1,2,3,3-	CF_3-CHF-	236ea	Claim 1 Formula (II):	*X = F*

hexafluoropropane (1,1,2,3,3,3-hexafluoropropane)[2]	CHF_2		$(CX_nY_{3-n})(CR^1_aR^2_b)_zCHXCH_{m+1}X_{2-m}$	*n = 3* *m = 0* *z = 0*
1,1,1,2,3-pentafluoropropane (1,2,3,3,3-pentafluoropropane)[3]	CF_3-CHF-CH_2F	245eb	Claim 1 Formula (II): $(CX_nY_{3-n})(CR^1_aR^2_b)_zCHXCH_{m+1}X_{2-m}$	*X = F* *n = 3* *m = 1* *z = 0*
2,3,3,3-tetrafluoropropene	$CF_3CF=CH_2$	1234yf	Claim 2 Formula (III): $(CX_nY_{3-n})(CR^1_aR^2_b)_zCX=CH_{m+1}X_{1-m}$	X=F n=3 m=1 z=0
1,1,1,2,3,3-	CF_3-CHF-	236ea	Claim 22 Formula (IIA):	*X = F*

[2] Using systematic naming conventions, the proper name of HFC-236ea is "**1,1,1,**2,3,3-hexafluoropropane." However, some references describe HFC-236ea as "1,1,2,**3,3,3**-hexafluoropropane." *See,e.g.*, Ex. 1003 at Abstract. Although the name "1,1,2,**3,3,3**-hexafluoropropane" technically does not comply with systematic naming conventions for organic compounds, a POSITA would understand that both names unambiguously describe HFC-236ea.

[3] Using systematic naming conventions, the proper name of HFC-245eb is "**1,1,1**,2,3-pentafluoropropane." However, some references describe HFC-245eb as "1,2,**3,3,3**-pentafluoropropane." *See,e.g.*, Ex. 1003 at Abstract. Although the name "1,2,**3,3,3**-pentafluoropropane" technically does not comply with systematic naming conventions for organic compounds, a POSITA would understand that both names unambiguously describe HFC-245eb.

hexafluoropropane (1,1,2,3,3,3-hexafluoropropane)[2]	CHF_2		$(CX_nY_{3-n})CHXCH_{m+1}X_{2-m}$	*n = 3* *m = 0*
1,1,1,2,3-pentafluoropropane (1,2,3,3,3-pentafluoropropane)[3]	CF_3-CHF-CH_2F	245eb	Claim 22 Formula (IIA): $(CX_nY_{3-n})CHXCH_{m+1}X_{2-m}$	*X = F* *n = 3* *m = 1*
1,2,3,3,3-pentafluoropropene (1,1,1,2,3-pentafluoropropene)[4]	$CF_3CF=CHF$	1225ye	Claim 24 Formula (IIIA): $(CX_nY_{3-n})CX=CH_{m+1}X_{1-m}$	*X = F* *n = 3* *m = 0*
2,3,3,3-tetrafluoropropene	$CF_3CF=CH_2$	1234yf	Claim 24 Formula (IIIA): $(CX_nY_{3-n})CX=CH_{m+1}X_{1-m}$	*X = F* *n = 3* *m = 1*

IX. State of the Art as of October 12, 2010

57. As of October 12, 2010, processes for manufacturing fluorinated olefins including 1234yf and 1225ye were known as seen in *Smith*. As admitted in the background section of the '282 patent and demonstrated in *Smith*, all of the chemistry involved in manufacturing 1225ye and 1234yf was known including

[4] Using systemic naming conventions, the proper name of HFO-1225ye is "1,2,**3,3,3**-pentafluoropropene." However, some references describe HFO-1225ye as "**1,1,1**,2,3-pentafluoropropene." Although the name "**1,1,1**,2,3-pentafluoropropene" technically does not comply with systematic naming conventions for organic compounds, a POSITA would understand that both names unambiguously describe HFO-1225ye.

hydrogenation and dehydrohalogenation with KOH. Methods of withdrawing, recovering, and recycling alkali metal hydroxide in a dehydrohalogenation process were also known as set forth in *Masayuki*. Further, methods of converting by-product alkali metal halide salt (KF) back to alkali metal hydroxide (KOH) were also known as set forth in *Harrison*. As *Douglas* explains, it was a "rule of thumb" in chemical process design that it is desirable to recover more than 99% of all valuable materials through recovering and recycling. Ex. 1016 at bottom of p. 116-117. As noted above, I understand that October 12, 2010 is the relevant date for assessing the state of the art. *See supra* ¶ 43. *Smith*, *Masayuki*, *Harrison* and *Douglas* were all published prior to October 12, 2010, and are thus reflective of the state of the art as of that date.

58. *Smith* describes a process for preparing fluorinated olefins including hydrogenating HFP to yield 236ea (step (a) of *Smith*) and hydrogenating 1225ye to yield 245eb (step (c) of *Smith*). Ex. 1003 at 1:23-2:2. Hydrogenation of HFP and 1225ye may be conducted simultaneously in the same reactor to produce both 236ea and 245eb. *Id*. at 2:29-3:5.

59. *Smith* further describes optionally separating 236ea and 245eb after simultaneous hydrogenation and before dehydrofluorination. 236ea and 245eb may be separated from each other (e.g., by distillation) before being fed into

separate dehydrofluorination reactors for carrying out dehydrofluorination steps (b) and (d). *Id*. at 3:5-7.

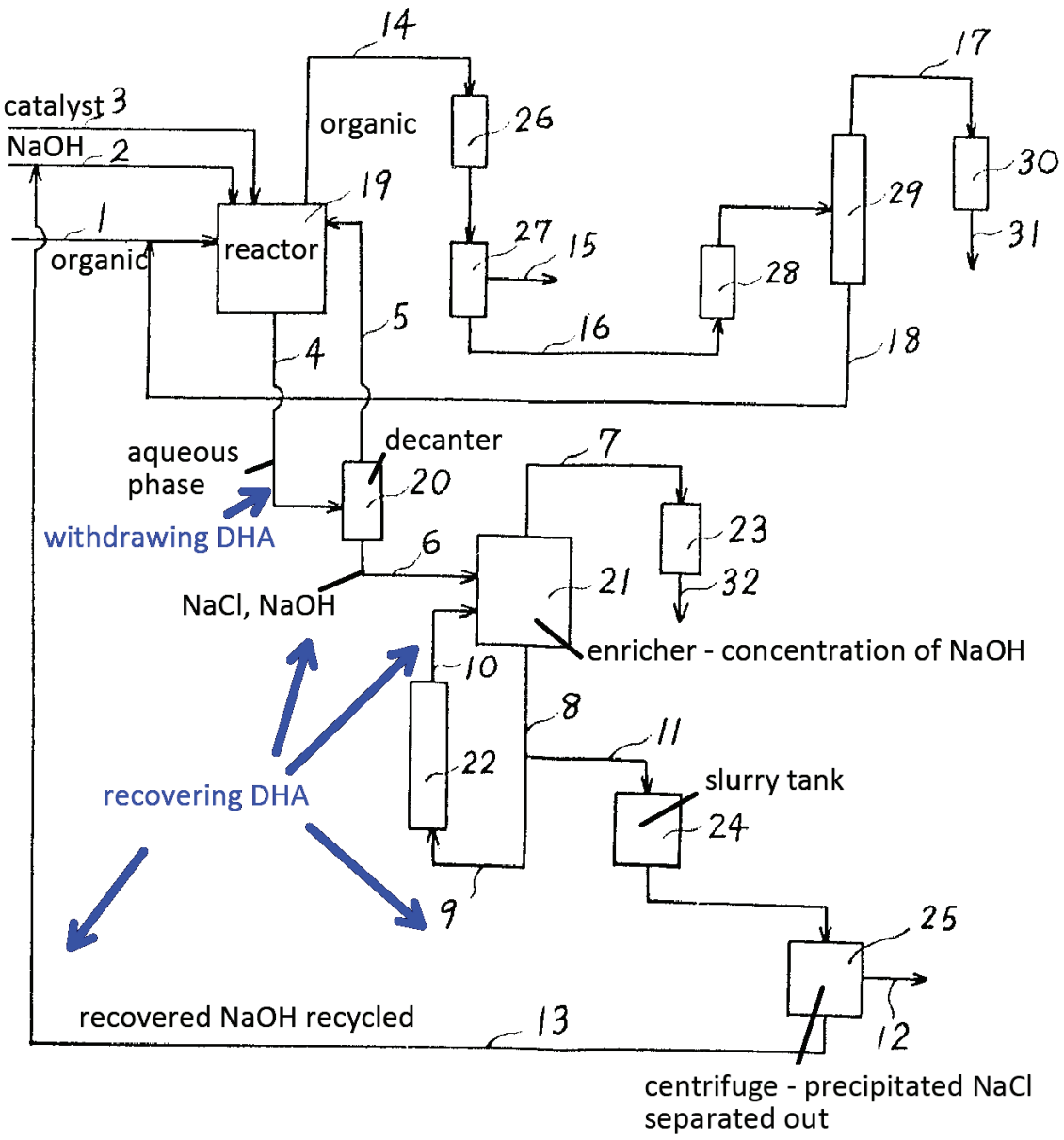
60. *Smith* also describes dehydrofluorinating 236ea and 245eb using KOH to produce 1225ye and 1234yf, respectively (steps (b) and (d) of *Smith*). *Id*. at 1:23-2:2 and 11:9-15. *Smith* describes dehydrofluorination of 236ea and 245eb being carried out in separate reactors (as mentioned above) and simultaneously in the same reactor. For example, separate feeds may be fed to a single reactor in which steps (b) and (d) are carried out simultaneously. *Id*. at 3:4-14. According to *Smith*, a preferred solvent for the dehydrofluorinating reaction is water. *Id.* at 12:26-27.

61. *Smith* also describes that the products from any of steps (a), (b), (c), and/or (d) may be subjected to a purification step, which may be achieved by separation of products or reagents by one or more known separation techniques. *Id*. at 2:10-14. Exemplary separation techniques include distillation, condensation, and phase separation. *Id*.

62. *Masayuki* describes a process for producing chloroprene (2-chloro-butadiene-1,3) by dehydrochlorinating 3,4-dichloro-butene-1 using an aqueous solution of alkali metal hydroxide. Ex. 1005 at 4:2-4, 6:14-19. According to *Masayuki*, "the alkali metal hydroxide used for the present invention is typically sodium hydroxide …, but hydroxides of metals such as potassium, lithium, etc. can also be used." *Id*. at 6:37-7:2. In the dehydrochlorination process of *Masayuki*,

3,4-dichloro-butene-1 is dehydrochlorinated in an aqueous solution containing a relatively high concentration of an alkali metal hydroxide (e.g., NaOH) in the presence of an organic catalyst to produce a gaseous mixture containing chloroprene, unreacted 3,4-dichloro-butene-1, and water vapor and an aqueous phase comprising alkali metal hydroxide and alkali metal chloride (e.g., NaCl). *Id*. at 6:14-33. The gaseous mixture and aqueous phase are removed from the reactor separately. *Id*. at 10:33-34 (water phase) and 11:24-25 (gas phase mixture). Water is evaporated from the aqueous phase, increasing the concentration of alkali metal hydroxide in the aqueous phase and resulting in precipitation of alkali metal chloride. *Id*. at 6:28-33. The solid alkali metal chloride is separated and removed from the aqueous phase, *id*. at 11:9-14, and the concentrated aqueous alkali metal hydroxide is recycled to the dehydrochlorination reaction. *Id*. at 11:14-16.

63. Example 1 and the accompanying Figure (annotated copy provided below) illustrate the process taught in *Masayuki*. In Example 1, a mixture of fresh 3,4-dichloro-butene-1 (conduit 1), recovered 3,4-dichlorobutene-1 (conduit 18), 50% by weight sodium hydroxide aqueous solution (conduit 2), and the catalyst lauryl trimethyl ammonium chloride (conduit 3) are fed into a stirred reactor 19. *Id*. at 10:23-30.



64. The aqueous phase resulting from the dehydrochlorination reaction is extracted via conduit 4 such that the level of the reactor 19 remains constant. *Id.* at 10:33-35. The aqueous phase leaving the reactor 19 has a lipid phase present therein, which is separated from the aqueous phase using the decanter 20 and is returned to the reactor 19 via conduit 5. *Id.* at 10:35-11:1. The aqueous phase,

which contains unreacted NaOH and NaCl in solution and also precipitated sodium chloride, is fed to a loop comprising a circulation-type enricher 21 via conduit 6, where concentration of the aqueous phase is carried out through evaporation. *Id*. at 11:1-5. In the loop, the aqueous phase passes through conduit 8 and 9, is heated in heat exchanger 22, and is circulated back to the enricher 21 via conduit 10. *Id*. at 11:6-9. As water evaporates, dissolved sodium chloride precipitates out of the aqueous phase. *Id*. at 11:9-10. The aqueous phase containing concentrated NaOH solution and precipitated NaCl is extracted from the loop via conduit 8, directed into a slurry tank 24 via conduit 11, and fed into a centrifuge 25 where the precipitated NaCl is separated out and discarded via conduit 12. *Id*. at 11:10-14. The aqueous phase containing concentrated, recovered sodium hydroxide is returned to conduit 2 via conduit 13 and recycled to the dehydrochlorination reaction (reactor 19). *Id*. at 11:14-16.

65. *Harrison* describes a process for converting alkali metal salt to alkali metal hydroxide using lime ($Ca(OH)_2$). Initially, industrial waste waters containing fluoride are contacted with aqueous potassium hydroxide to obtain an aqueous solution of potassium fluoride and potassium hydroxide (HF + excess KOH → KOH + KF + H_2O). Then, the solution of the initial step is contacted with finely divided high purity lime ($Ca(OH)_2$) in a conversion step to obtain a calcium fluoride precipitate in aqueous potassium hydroxide (KF + KOH + $Ca(OH)_2$ →

CaF_2 + KOH). Next, the reaction product of the conversion step is settled into two phases comprising an aqueous potassium hydroxide supernatant and an aqueous slurry of calcium fluoride. The aqueous potassium hydroxide supernatant is recovered. Ex.1006 at 2:10-21.

X. Claims 1-46 are Obvious over Smith in View of Masayuki and Harrison

A. Basis of my Analysis with Respect to Obviousness

66. It is my understanding that once prior art is identified, an obviousness analysis involves comparing a claim to the prior art to determine whether the claimed invention would have been obvious to a POSITA in light of that art, and in light of the general knowledge in the art. It is my understanding that obviousness can be established by combining or modifying the teachings of the prior art to achieve the claimed invention. It is also my understanding that where there is a reason to modify or combine the prior art to achieve the claimed invention, there must also be a reasonable expectation of success in combining the prior art to arrive at the claimed invention. It is my understanding that in an obviousness determination the entire disclosure of the prior art is considered, even portions that would dissuade a POSITA from making or using the claimed invention. It is also my understanding that one way to rebut a finding of obviousness is to present evidence of secondary considerations of nonobviousness, such as unexpected

results, commercial success, long felt but unsolved need, and the failure of others to achieve the claimed invention.

B. Claim 21 of the '282 Patent is Obvious over Smith in view of Masayuki and Harrison

67. Independent claim 21 of the '282 patent recites a process for the manufacture of a fluoroolefin comprising: (a) dehydrohalogenating a haloalkane in the presence of KOH to produce a haloalkene; (b) withdrawing a reaction stream comprising spent KOH; and (c) recovering spent KOH. The combination of *Smith*, *Masayuki*, and *Harrison* describes all of the steps of claim 21.

68. As will be explained in more detail below, a POSITA would be motivated to combine the teachings of *Smith*, *Masayuki*, and *Harrison* to arrive at the invention of claim 21. *Smith* discloses dehydrofluorinating a fluoroalkane in the presence of KOH to produce a fluoroalkene, which is the chemistry recited in claim 21. As mentioned above, it is a "rule of thumb" in chemical process design to try to recover and re-use as much valuable material as possible in a process. Further, operating as efficiently and economically as possible is always a goal in chemical processing. Thus, as with any process, a POSITA would be motivated to try to recover and recycle as much valuable material (e.g., dehydrohalogenating agent) as possible from the reactions described in *Smith*. To do so, the skilled artisan would look to analogous, base-mediated dehydrohalogenation processes for suggestions

of how to recover and/or recycle unreacted KOH and by-product salt of the KOH (e.g., KF) formed in the reaction. The search for analogous processes would lead to *Masayuki,* which teaches a method for recovering and recycling unreacted alkali metal hydroxide in an analogous, base-mediated dehydrohalogenation process. *Masayuki* also provides a flow diagram of a base-mediated dehydrohalogenation process, which a POSITA could use as a guide in implementing the recovery and recycling steps in *Masayuki*. A POSITA would thus be motivated to apply the steps of *Masayuki* to the dehydrohalogenation process described in *Smith* to recover and recycle the unreacted, spent alkali metal hydroxide (KOH) that remains after the dehydrohalogenation reaction and would have a reasonable expectation of success in doing so. To make the dehydrohalogenation process of *Smith* even more efficient and cost effective, a POSITA would be motivated to increase the amount of KOH recovered and recycled to the dehydrohalogenation reaction and to make productive use of the KF by-product salt. To that end, *Harrison* teaches a method for converting by-product salt KF back to KOH using $Ca(OH)_2$, which would enable an increase in recovery and recycle of KOH to the dehydrohalogenation process in *Smith*, and sale of CaF_2 to increase cost efficiency.

69. Turning to the elements of claim 21, *Smith* describes step (a), *Masayuki* describes step (b), and the combination of *Masayuki* and *Harrison* describes step (c).

70. *Smith* describes step (a) of claim 21, namely, dehydrohalogenating a haloalkane in the presence of KOH to produce a haloalkene. In particular, *Smith* discloses "a process for the preparation of 1234yf comprising … (b) dehydrofluorinating 236ea to produce 1,2,3,3,3-pentafluoropropene (referred to hereinafter as 1225ye); … and (d) dehydrofluorinating 245eb to produce 1234yf ." Ex. 1003 at 1:23-2:2. *Smith* explains that 236ea is 1,1,2,3,3,3-hexafluoropropane,[2] 1225ye is 1,2,3,3,3-pentafluoropropene, 245eb is 1, 2, 3,3,3-pentafluoropropane,[3] and 1234yf is 2,3,3,3-tetrafluoropropene. Ex.1003 at Abstract; 1:3-4. *Smith* also explains that a preferred method for performing dehydrofluorination is by contacting 236ea and/or 245eb with a basic metal hydroxide, *id*. at 11:9-12, for example, potassium hydroxide (KOH). *Id*. at 11:13-15. A preferred solvent for the dehydrofluorination reaction is water. *Id.* at 12:26-27. *Smith* also explains that the products from any of steps (a), (b), (c), and/or (d) can be purified. Exemplary purification can be achieved by separation of the products or reagents by one or more known separation techniques, such as, for example, distillation, condensation, or phase separation. Ex. 1003 2:10-14.

71. *Masayuki* describes withdrawing a reaction stream comprising spent DHA (e.g., NaOH or KOH) from a reactor. *Masayuki* also describes a base-mediated dehydrohalogenation process, in particular, dehydrochlorinating 3,4-dichloro-butene-l using an aqueous solution of alkali metal hydroxide (e.g., NaOH or KOH)

to produce chloroprene and an alkali metal halide (e.g., NaCl or KCl). Ex. 1005 at 6:14-33, 6:37-7:2. In an example of the process described in *Masayuki*, an aqueous phase containing unreacted NaOH and by-product salt (NaCl) is present in the reactor 19 after the dehydrohalogenation reaction and is withdrawn from the reactor via conduit 4 for additional processing. Ex.1005 at 10:33-35. In the example of *Masayuki,* an aqueous phase comprising spent DHA and alkali metal halide salt are withdrawn from the dehydrohalogenation reactor.

72. A POSITA would be motivated to apply the withdrawing step of *Masayuki* to the dehydrohalogenation process of *Smith* thereby resulting in withdrawing an aqueous phase (i.e., a "reaction stream") comprising spent KOH (and by-product KF) from the dehydrofluorination reactor, as recited in step (b) of claim 21.

73. *Masayuki* in combination with *Harrison* describes step (c) of claim 21, namely, recovering spent KOH. *Masayuki* teaches that the aqueous phase that is withdrawn from the reactor 19 via conduit 4, as described above, is introduced to a separator (specifically a decanter 20) wherein an organic lipid phase is separated and removed via conduit 5 from the aqueous phase. Ex.1005 at 10:33-11:1. The aqueous phase is introduced to a loop including a circulation-type enricher 21 and a heat exchanger 22 via conduit 6. See, Ex. 1005 at 11:1-9, Figure. The aqueous phase is concentrated in the loop, leading to precipitation of alkali metal chloride and concentration of alkali metal hydroxide in the aqueous phase. Ex. 1005 at

11:9-14. The aqueous phase is then transported via conduit 11 to the slurry tank 24 and then to the centrifuge 25, where alkali metal chloride precipitate is separated from the aqueous phase, leading to the recovery of an aqueous phase comprising a concentrated solution of alkali metal hydroxide. *Id*. at 11:9-14. As explained above, when the withdrawing step of *Masayuki* is applied to the dehydrofluorination process of *Smith*, an aqueous reaction stream comprising spent KOH (and by-product KF) is withdrawn from the dehydrofluorination reactor of *Smith*. Applying the decanting step of *Masayuki*, as described above, to this withdrawn reaction stream results in the recovery of spent KOH as an aqueous mixture of KOH and KF (step (c) of claim 21).

74. *Harrison* describes a well-known process of converting KF in an aqueous mixture of KOH and KF to KOH by treating the mixture with $Ca(OH)_2$, slaked lime. Ex. 1006 at 2:14-16, 3:6-10. According to *Harrison*, "[l]ime softening or treating of water for fluoride removal is a well-known and established process for fluoride reduction." Ex.1006 at 1:18-20. Thus, it would be obvious that the KF by-product in the aqueous phase of *Smith* could be converted back to KOH using the process of *Harrison*. Further, in the process of *Smith* in combination with *Masayuki*, it would be desirable to increase the amount of KOH recovered for re-use in the dehydrofluorination process and to have a productive use for the by-product KF. Applying the KOH conversion step of *Harrison* to the decanted

aqueous mixture of KOH and KF from the process of *Smith* in combination with *Masayuki* results in the desired recovery of additional aqueous KOH and productive use of KF by-product (i.e., by converting the KF to KOH and CaF_2). Further, a POSITA would understand that the conversion step of *Harrison* could be implemented relatively easily in the slurry tank 24 of *Masayuki* by introducing $Ca(OH)_2$ to the slurry tank 24. The other processing steps in *Masayuki* could remain the same.

75. In the combined process of *Smith*, *Masayuki*, and *Harrison*, a POSITA would understand that the dehydrofluorination reaction of *Smith* would take place in the reactor 19 of *Masayuki*. The remainder of the process of *Masayuki* would operate substantially as taught in *Masayuki,* with a small modification at the slurry tank 24 for the introduction of $Ca(OH)_2$ into the slurry tank 24 to convert KF to KOH and CaF_2. As with the NaCl precipitate formed in *Masayuki*, CaF_2 precipitate formed in the KF conversion reaction would be separated from the aqueous phase in the centrifuge 25 and would be removed via conduit 12. The concentrated aqueous KOH comprising spent and converted KOH would be recycled to the reactor 19 via conduit 13 and then conduit 2.

76. The conversion step of *Harrison* improves the recovering and recycling process of *Masayuki* because it enables recovery and recycling of more KOH. In addition, the aqueous phase comprising the spent and recovered KOH has a higher

purity due to the conversion of the KF by-product back to KOH. The conversion process of *Harrison* provides a method to easily increase the efficiency of the process of *Smith* in combination with *Masayuki*. Thus, a POSITA would have been motivated to apply the method of *Harrison* to the dehydrofluorination process of *Smith*, as modified by *Masayuki*, in order to increase the recovery of spent KOH and to utilize the KF by-product.

77. A POSITA would have a reasonable expectation of success in combining the processes of *Smith* and *Masayuki* because these references describe very similar processes, namely the aqueous, base-mediated dehydrohalogenation of a halogenated organic compound, which produce organic products and an aqueous phase comprising unreacted (spent) DHA and a by-product salt of the DHA. *Smith* describes dehydrofluorinating 245eb using an aqueous solution of KOH to produce 1234yf and KF, with unreacted KOH and water being present in the reaction mixture. *Masayuki* describes dehydrochlorinating 3,4-dichloro-butene-l using an aqueous solution of NaOH (or KOH) to produce chloroprene and NaCl (or KCl), with unreacted NaOH (or KOH) and water being present in the reaction medium. The dehydrohalogenation reactions of *Smith* and *Masayuki* proceed similarly, with the alkali metal hydroxide reacting with the organic reagent to produce the desired organic product and a by-product salt. Thus, a POSITA would have a reasonable expectation that a process for recovering the alkali metal hydroxide for one

dehydrohalogenation process would be effective for doing the same in the other dehydrohalogenation process. A POSITA would further have a reasonable expectation of success in combining *Harrison* with the combined process of *Smith* and *Masayuki* because both *Harrison* and the combined process of *Smith* and *Masayuki* involve an aqueous solution of KOH and KF. Additionally, the process of *Harrison* was a well-known process for converting KF to KOH, so a POSITA would have reasonably expected the conversion process to work effectively to recover KOH and make productive use of by-product KF. Additionally, a POSITA would consider applying the converting step of *Harrison* to *Masayuki* to be straightforward, causing little to no disruption to the process of *Masayuki.*

78. Accordingly, in my opinion, the combination of *Smith*, *Masayuki,* and *Harrison* sets forth the elements of claim 21 in such a manner that a POSITA would have been able to practice the method of claim 21 with a reasonable expectation of success.

'282 patent claim	Disclosure from *Smith* (Ex. 1003)
21. A process for the manufacture of a fluoroolefin comprising: (a) dehydrohalogenating a haloalkane in the presence of KOH to produce a haloalkene;	"The subject invention addresses the deficiencies of the known methods for preparing 1234yf by providing a process for the preparation of 1234yf comprising …(b) dehydrofluorinating 236ea to produce 1,2,3,3,3-pentafluoropropene (referred to hereinafter as 1225ye); … and (d) dehydrofluorinating 245eb to produce 1234yf ." (**Ex. 1003 at 1:23-2:2**.) "Another preferred method of effecting the dehydrofluorination in steps (b) and (d) is by contacting 236ea and/or 245eb with a base. Preferably, the base is a

	metal hydroxide …, e.g. an alkali or alkaline earth metal hydroxide or amide). … the term "alkali metal hydroxide" [refers] to a compound or mixture of compounds selected from lithium hydroxide, sodium hydroxide, potassium hydroxide, rubidium hydroxide and caesium hydroxide." (**Ex. 1003 at 11: 9-15**.)	
Claim 21 (cont.)	Disclosure from *Masayuki* (Ex. 1005)	
(b) withdrawing a reaction stream comprising spent KOH; and	(**Ex. 1005 Figure, stream 4**.) "The aqueous phase was extracted via Conduit 4 such that the level of Reactor 19 remained constant" (**Ex.1005 at 10:33-35**.)	
Claim 21 (cont.)	Disclosure from *Masayuki* (Ex. 1005)	Disclosure from *Harrison* (Ex. 1006)
(c) recovering spent KOH.	(**Ex. 1005 Figure, decanter 20, enricher 21, centrifuge 25**.) "The aqueous phase was extracted via Conduit 4 such that the level of Reactor 19 remained constant and the lightly mixed lipid and aqueous phases (including precipitated sodium chloride) were separated using Decanter 20, after which the lipid phase was returned to the reactor via Conduit 5." (**Ex. 1005 at 10:33-11:1**.) "The aqueous phase … was fed into a forced circulation-type Enricher 21 via Conduit 6 and concentration was carried out[.] After passing through Conduit 9 from Conduit 8, the aqueous phase	" . . . (b) contacting [an aqueous solution of potassium fluoride and potassium hydroxide] with finely divided high purity lime to thereby obtain a calcium fluoride precipitate in aqueous potassium hydroxide; (c) settling the reaction product of step (b) into two phases comprising an aqueous potassium hydroxide supernatant and an aqueous slurry of calcium fluoride; (d) recovering the aqueous potassium hydroxide supernatant . . ." (**Ex.1006 at 2:14-21**.) "The basic potassium fluoride solution is then mixed with solid hydrated (slaked) lime in a stirred vessel where this calcium hydroxide [$Ca(OH)_2$]

	was heated in Heat Exchanger 22 after which it was circulated in Enricher 21 via Conduit 10." (**Ex. 1005 at 11:1-9**.) "As concentration was performed, dissolved sodium chloride precipitated out, but said aqueous phase was extracted via Conduit 8, directed into Slurry Tank 24 via Conduit 11 and fed into Centrifuge 25 where precipitated sodium chloride was separated out and also discarded via Conduit 12." (**Ex.1005 at 11:9-14**.)	reacts to form the calcium fluoride precipitate and regenerate the potassium hydroxide." (**Ex. 1006 at 3:6-10**.)

C. Claim 36 of the '282 Patent is Obvious over Smith in view of Masayuki and Harrison

79. Independent claim 36 is the same as claim 21 except it requires specific alkanes and alkenes, i.e., dehydrohalogenating 236ea or 245eb in the presence of KOH to produce 1234yf or 1225ye. *Smith* describes dehydrofluorination of 236ea to produce 1225ye and dehydrofluorination of 245eb to produce 1234yf. Ex. 1003 at 1:23-2:2. A POSITA would understand that dehydrofluorination is a dehydrohalogenating reaction.

80. In my opinion, claim 36 is otherwise obvious in view of the combination of *Smith, Masayuki,* and *Harrison* for all of the same reasons that claim 21 is obvious as explained above.

'282 patent claim	Disclosure from *Smith* (Ex. 1003)
36. A process for the manufacture of a fluoroolefin comprising: (a) dehydrohalogenating 1,1,1,2,3,3-hexafluoropropane (HFC-236ea) [1,1,2,3,3,3-hexafluoropropane (236ea)] or 1,1,1,2,3-pentafluoropropane (HFC-245eb) [1,2,3,3,3-pentafluoropropane (245eb)] in the presence of KOH to produce 2,3,3,3-tetrafluoropropene (HFO-1234yf) or 1,2,3,3,3-pentafluoropropene (HFO-1225ye);	"The subject invention addresses the deficiencies of the known methods for preparing 1234yf by providing a process for the preparation of 1234yf comprising …(b) dehydrofluorinating 236ea to produce 1,2,3,3,3-pentafluoropropene (referred to hereinafter as 1225ye); … and (d) dehydrofluorinating 245eb to produce 1234yf ." (**Ex. 1003 at 1:23-2:2**.) "Another preferred method of effecting the dehydrofluorination in steps (b) and (d) is by contacting 236ea and/or 245eb with a base. Preferably, the base is a metal hydroxide …, e.g. an alkali or alkaline earth metal hydroxide or amide). … the term "alkali metal hydroxide" [refers] to a compound or mixture of compounds selected from lithium hydroxide, sodium hydroxide, potassium hydroxide, rubidium hydroxide and caesium hydroxide." (**Ex. 1003 at 11: 9-15**.)

Claim 36 (cont.)	Disclosure from *Masayuki* (Ex. 1005)
(b) withdrawing a reaction stream comprising spent KOH; and	(**Ex. 1005 Figure, stream 4**.) "The aqueous phase was extracted via Conduit 4 such that the level of Reactor 19 remained constant" (**Ex.1005 at 10:33-35**.)

Claim 36 (cont.)	Disclosure from *Masayuki* (Ex. 1005)	Disclosure from *Harrison* (Ex. 1006)
(c) recovering spent KOH.	(**Ex. 1005 Figure, decanter 20, enricher 21, centrifuge 25**.) "The aqueous phase was extracted via Conduit 4 such that the level of Reactor 19 remained constant and the lightly mixed lipid and aqueous phases (including precipitated sodium	" . . . (b) contacting the solution of step (a) with finely divided high purity lime to thereby obtain a calcium fluoride precipitate in aqueous potassium hydroxide; (c) settling the reaction product of step (b) into two phases comprising an aqueous potassium hydroxide supernatant

	chloride) were separated using Decanter 20, after which the lipid phase was returned to the reactor via Conduit 5." (**Ex. 1005 at 10:33-11:1**.) "The aqueous phase … was fed into a forced circulation-type Enricher 21 via Conduit 6 and concentration was carried out[.] After passing through Conduit 9 from Conduit 8, the aqueous phase was heated in Heat Exchanger 22 after which it was circulated in Enricher 21 via Conduit 10." (**Ex. 1005 at 11:1-9**.) "As concentration was performed, dissolved sodium chloride precipitated out, but said aqueous phase was extracted via Conduit 8, directed into Slurry Tank 24 via Conduit 11 and fed into Centrifuge 25 where precipitated sodium chloride was separated out and also discarded via Conduit 12." (**Ex.1005 at 11:9-14**.)	and an aqueous slurry of calcium fluoride; (d) recovering the aqueous potassium hydroxide supernatant . . ." (**Ex.1006 at 2:14-21**.) "The basic potassium fluoride solution is then mixed with solid hydrated (slaked) lime in a stirred vessel where this calcium hydroxide [$Ca(OH)_2$] reacts to form the calcium fluoride precipitate and regenerate the potassium hydroxide." (**Ex. 1006 at 3:6-10**.)

D. Claims 22 and 23 of the '282 Patent are Obvious over Smith in view of Masayuki and Harrison

81. Claim 22 depends from claim 21 and claim 23 depends from claim 22. Claim 22 defines the haloalkane as a compound of Formula (IIA): $(CX_nY_{3-n})CHXCH_{m+1}X_{2-m}$, wherein each X is independently selected form the group consisting of Cl, F, I and Br; each Y is independently selected from the group consisting of H, Cl, F, I, and Br; n is 1, 2, or 3; and m is 0, 1 or 2. Claim 23 defines the haloalkane as 1,1,1,2,3,3-hexafluoropropane (HFC-236ea) or 1,1,1,2,3-pentafluoropropane (HFC-245eb). *Smith* describes dehydrofluorination of 1,2,3,3,3-pentafluoropropane (245eb) and 1,1,2,3,3,3-hexafluoropropane (236ea), which fall within the scope of the formula set forth in claim 22 (when X is F, n is 3 and m is 1 for 245eb and when X is F, n is 3 and m is 0 for 236ea). Ex. 1003 at 1:23-2:2. Claim 23 requires 236ea and 245eb, which are disclosed in *Smith. Id*. The following explanation demonstrates how 236ea and 245eb fall within the scope of Formula (IIA) of claim 22:

- 236ea has the formula CF_3-CHF-CHF_2, and therefore falls within the scope of formula IIA, $(CX_nY_{3-n})CHXCH_{m+1}X_{2-m}$, when X is F, n is 3 and m is 0. When X, n, and m have these values, as permitted by claim 22, formula IIA becomes $(CF_3Y_{3-3})CHFCH_{0+1}F_{2-0}$ or CF_3-CHF-CHF_2, which is 236ea.

- 245eb has the formula CF_3-CHF-CH_2F, and therefore falls within the scope of formula IIA, $(CX_nY_{3-n})CHXCH_{m+1}X_{2-m}$, when X is F, n is 3 and m is 1. When X, n, and m have these values, as permitted by claim 22, formula IIA becomes $(CF_3Y_{3-3})CHFCH_{1+1}F_{2-1}$ or CF_3-CHF-CH_2F, which is 245eb.

82. In my opinion, the combination of *Smith*, *Masayuki*, and *Harrison* sets forth the elements of claims 22 and 23 in such a manner that a POSITA would have been able to practice the method of claim 22 with a reasonable expectation of success.

'282 patent claim	Disclosure from *Smith* (Ex. 1003)
22. The process of claim 21 wherein the haloalkane is comprised of a compound of formula (IIA): $(CX_nY_{3-n})CHXCH_{m+1}X_{2-m}$ (IIA) wherein each X is independently selected from the group consisting of Cl, F, I and Br; each Y is independently selected from the group consisting of H, Cl, F, I, and Br; n is 1, 2, or 3; and m is 0, 1 or 2.	"The subject invention addresses the deficiencies of the known methods for preparing 1234yf by providing a process for the preparation of 1234yf comprising …(b) dehydrofluorinating 236ea to produce 1,2,3,3,3-pentafluoropropene (referred to hereinafter as 1225ye); … and (d) dehydrofluorinating 245eb to produce 1234yf ." (**Ex. 1003 at 1:23-2:2**.)
23. The process of claim 22 wherein the haloalkane is 1,1,1,2,3,3-hexafluoropropane (HFC-236ea) or 1,1,1,2,3-pentafluoropropane (HFC-245eb).	"The subject invention addresses the deficiencies of the known methods for preparing 1234yf by providing a process for the preparation of 1234yf comprising …(b) dehydrofluorinating 236ea to produce 1,2,3,3,3-pentafluoropropene (referred to hereinafter as 1225ye); … and (d) dehydrofluorinating 245eb to

	produce 1234yf ." (**Ex. 1003 at 1:23-2:2**.)

E. Claims 24 and 25 of the '282 Patent are Obvious over Smith in view of Masayuki and Harrison

83. Claim 24 depends from claim 21, and claim 25 depends from claim 24. Claim 24 defines the haloalkene as a compound of formula (IIIA): $(CX_nY_{3-n})CX=CH_{m+1}X_{1-m}$ (IIIA), wherein each X is independently selected from the group consisting of Cl, F, I and Br; each Y is independently selected from the group consisting of H, Cl, F, I, and Br; n is 1, 2, or 3; and m is 0 or 1. Claim 25 defines the haloalkene as 2,3,3,3-tetrafluoropropene (HFO-1234yf) or 1,2,3,3,3-pentafluoropropene (HFO-1225ye). *Smith* describes the dehydrofluorination of haloalkanes to produce 2,3,3,3-tetrafluoropropene (1234yf) and 1,2,3,3,3-pentafluoropropene (1225ye), which fall within the scope of the formula set forth in claim 24 (when X is F, n is 3, and m is 1 for 1234yf; and when X is F, n is 3, and m is 0 for 1225ye). Ex. 1003 at 1:23-2:2. Claim 25 specifically recites 1234yf and 1225ye, which are disclosed in *Smith*. The following explanation demonstrates how 1225ye and 1234yf fall within the scope of Formula (IIIA) of claim 24:

- 1,2,3,3,3-pentafluoropropene (1225ye) has the formula $CF_3CF=CHF$, and

therefore falls within the scope of formula IIIA, $(CX_nY_{3-n})CX=CH_{m+1}X_{1-m}$, when X

is F, n is 3, and m is 0. When X, n, and m have these values, as permitted by claim 24, $(CX_nY_{3-n})CX=CH_{m+1}X_{1-m}$ becomes $(CF_3Y_{3-3})CF=CH_{0+1}F_{1-0}$ or $CF_3CF=CHF$, which is 1225ye.

- 2,3,3,3-tetrafluoropropene (1234yf) has the formula $CF_3CF=CH_2$, and

therefore falls within the scope of formula IIIA, $(CX_nY_{3-n})CX=CH_{m+1}X_{1-m}$, when X is F, n is 3, and m is 1. When X, n, and m have these values, as permitted by claim 24, $(CX_nY_{3-n})CX=CH_{m+1}X_{1-m}$ becomes $(CF_3Y_{3-3})CF=CH_{1+1}F_{1-1}$ or $CF_3CF=CH_2$, which is 1234yf.

84. Accordingly, in my opinion, the combination of *Smith*, *Masayuki*, and *Harrison* sets forth the elements of claims 24 and 25 in such a manner that a POSITA could have been able to practice the method of claims 24 and 25 with a reasonable expectation of success.

'282 patent claim	Disclosure from *Smith*
24. The process of claim 21 wherein the haloalkene is comprised of a compound of formula (IIIA): $(CX_nY_{3-n})CX=CH_{m+1}X_{1-m}$ (IIIA) wherein each X is independently selected from the group consisting of Cl, F, I and Br; each Y is independently selected from the group consisting of H, Cl, F, I, and Br; n is 1, 2, or 3; and m is 0 or 1.	"The subject invention addresses the deficiencies of the known methods for preparing 1234yf by providing a process for the preparation of 1234yf comprising …(b) dehydrofluorinating 236ea to produce 1,2,3,3,3-pentafluoropropene (referred to hereinafter as 1225ye); … and (d) dehydrofluorinating 245eb to produce 1234yf ." (**Ex. 1003 at 1:23-2:2**.)
25. The process of claim 24 wherein the haloalkene is 2,3,3,3-tetrafluoropropene (HFO-1234yf) or 1,2,3,3,3-	"The subject invention addresses the deficiencies of the known methods for preparing 1234yf by

pentafluoropropene (HFO-1225ye).	providing a process for the preparation of 1234yf comprising …(b) dehydrofluorinating 236ea to produce 1,2,3,3,3-pentafluoropropene (referred to hereinafter as 1225ye); … and (d) dehydrofluorinating 245eb to produce 1234yf ." (**Ex. 1003 at 1:23-2:2**.)

F. Claims 26 and 37 of the '282 Patent are Obvious over Smith in view of Masayuki and Harrison

85. Claim 26 depends from claim 21, and claim 37 depends from claim 36. Both claims require that dehydrohalogenation occurs using a continuously stirred tank reactor. *Smith* describes carrying out the dehydrohalogenation process batch-wise or continuously, preferably continuously, using any suitable apparatus, including a stirred tank reactor. Ex.1003 at 2:5-7. It would have been obvious to use a continuously stirred tank reactor in a continuous process because the reaction mixture contains multiple phases of reactants and products (organic gas, organic liquid and aqueous) and continuous mixing facilitates the reaction of reactants present in different phases. Thus, it would have been obvious to use a continuously stirred reactor in the dehydrohalogenation reaction.

86. Accordingly, in my opinion, the combination of *Smith*, *Masayuki*, and *Harrison* sets forth the elements of claims 26 and 37 in such a manner that a POSITA would have been able to practice the method of claims 26 and 37 with a

reasonable expectation of success.

'282 patent claim	Disclosure from *Smith*
26. The process of claim 21 wherein the dehydrohalogenation occurs using a continuously stirred tank reactor.	"Each of steps (a) to (d) may be carried out batch-wise or continuously (preferably continuously), using any suitable apparatus, such as a static mixer, a tubular reactor, a stirred tank reactor or a stirred vapour-liquid disengagement vessel." (**Ex.1003 at 2:5-7**.)
37. The process of claim 36 wherein the dehydrohalogenation occurs using a continuously stirred tank reactor.	"Each of steps (a) to (d) may be carried out batch-wise or continuously (preferably continuously), using any suitable apparatus, such as a static mixer, a tubular reactor, a stirred tank reactor or a stirred vapour-liquid disengagement vessel." (**Ex.1003 at 2:5-7**.)

G. Claims 27 and 38 of the '282 Patent are Obvious over Smith in view of Masayuki and Harrison

87. Claim 27 depends from claim 21, and claim 38 depends from claim 36. Both claims specify that spent KOH is withdrawn from the reactor continuously or intermittently. *Smith* discloses that dehydrohalogenation may be carried out batch-wise or continuously using any suitable apparatus, including a stirred tank reactor. Ex.1003 at 2:5-7. *Masayuki* also discloses a continuous dehydrohalogenation process. Ex.1005 at 6:5-13. *Masayuki* describes extracting an aqueous phase from a dehydrohalogenation reactor such that the level in the reactor remains constant. Ex. 1005 at 10:33-35. In a continuous dehydrohalogenation process such as those disclosed in *Smith* and *Masayuki*, it would be obvious to withdraw spent alkali

metal hydroxide (e.g., spent KOH) from the dehydrohalogenation reactor continuously because reactants would be continuously added and products and by-products would be produced continuously, especially in view of *Masayuki's* disclosure of withdrawing the aqueous phase from the reactor such that a constant level is maintained in the reactor. If KOH were not removed continuously or intermittently, the reactor would fill completely and the reaction would come to a stop.

88. Accordingly, in my opinion, the combination of *Smith*, *Masayuki* and *Harrison* sets forth the elements of claims 27 and 38 in such a manner that a POSITA would have been able to practice the method of claims 27 and 38 with a reasonable expectation of success.

'282 patent claim	Disclosure from *Smith* (Ex. 1003)	Disclosure from *Masayuki* (Ex. 1005)
27. The process of claim 21 wherein the spent KOH is withdrawn from the reactor continuously or intermittently.	"Each of steps (a) to (d) may be carried out batch-wise or continuously (preferably continuously), using any suitable apparatus, such as a static mixer, a tubular reactor, a stirred tank reactor or a stirred vapour-liquid disengagement vessel." (**Ex.1003 at 2:5-7**.)	"The object of the present invention is the provision of a method for the production of chloroprene which shows a sufficiently high reaction speed, includes minimal production of undesirable byproducts such as l-chloro-butadiene-l,3, includes minimal loss of alkali metal hydroxide, does not produce wastewater during the dehydrochlorination process and does not readily result in clogging due to chloroprene polymer during long term continuous operation." (**Ex.1005 at 6:5-13**.) "The aqueous phase was extracted via

		Conduit 4 such that the level of Reactor 19 remained constant" (**Ex. 1005 at 10:33-35**.)
38. The process of claim 36 wherein the spent KOH is withdrawn from the reactor continuously or intermittently.	"Each of steps (a) to (d) may be carried out batch-wise or continuously (preferably continuously), using any suitable apparatus, such as a static mixer, a tubular reactor, a stirred tank reactor or a stirred vapour-liquid disengagement vessel." (**Ex.1003 at 2:5-7**.)	"The object of the present invention is the provision of a method for the production of chloroprene which shows a sufficiently high reaction speed, includes minimal production of undesirable byproducts such as l-chloro-butadiene-l,3, includes minimal loss of alkali metal hydroxide, does not produce wastewater during the dehydrochlorination process and does not readily result in clogging due to chloroprene polymer during long term continuous operation." (**Ex.1005 at 6:5-13**.) "The aqueous phase was extracted via Conduit 4 such that the level of Reactor 19 remained constant" (**Ex. 1005 at 10:33-35**.)

H. Claims 28 and 39 of the '282 Patent are Obvious over Smith in view of Masayuki and Harrison

89. Claim 28 depends from claim 21, and claim 39 depends from claim 36. Both claims recite "wherein the reaction stream further comprises a [sic] dissolved organics." As discussed above, the term "dissolved organics" means organic that is dissolved in a stream. *Smith* describes dehydrofluorination processes wherein organic co-solvents or diluents are used in combination with water and KOH in the aqueous phase. Exemplary solvents or diluents include fluorinated organics such as hexafluoroisopropanol, perfluorotetrahydrofuran, and perfluorodecalin in the

dehydrofluorination reaction mixture. Ex. 1003 12:27-13:4. Other prior art references also describe the use of non-aqueous solvents or co-solvents in base-mediated dehydrofluorination reactions wherein 236ea and 245eb are converted to 1225ye and 1234yf, respectively. For example, Knunyants, which published in 1960 and is therefore prior art to the '282 patent, discloses the use of an organic solvent in an exemplary base-mediated dehydrofluorination process wherein 236ea is converted to 1225ye using KOH. Ex. 1008 at 1316 ("Dehydrofluorination of 1,1,1,2,3,3-Hexafluoropropane"). Further, *Mahler,* which published November 12, 2009, and is therefore prior art to the '282 patent, discloses the dehydrofluorination of 245eb using an aqueous alkaline [KOH] solution, wherein a non-aqueous co-solvent in which 245eb is at least partially miscible is present. Ex. 1009 at ¶¶ [0052] and [0086]. Thus, one of ordinary skill in the art would be familiar with base-mediated dehydrofluorination processes wherein non-aqueous solvents in which organics, such as 245eb, were at least partially miscible were present during the reaction. Given the solubility of the fluoroalkane starting materials (e.g., 236ea and 245eb) of *Smith* in organic liquids, a POSITA would expect some portion of the organic starting materials of the dehydrofluorination reaction of *Smith* to be dissolved in the organic co-solvent or diluent component of the reaction stream. Accordingly, *Smith* teaches the reaction stream further comprising one or more dissolved organics. Accordingly, in my opinion, the combination of *Smith*,

Masayuki, and *Harrison* sets forth the elements of claims 28 and 39 in such a manner that a POSITA would have been able to practice the method of claims 28 and 39 with a reasonable expectation of success.

'282 patent claim	Disclosure from *Smith* (Ex. 1003)
28. The process of claim 21 wherein the reaction stream further comprises a dissolved organics.	"Thus, the dehydrofluorination reaction may preferably use an aqueous solution of at least one base … without the need for a co-solvent or diluent. However, a co-solvent or diluent can be used … to act as a preferred phase for reaction by-products…. Useful co-solvents or diluents include those that are not reactive with or negatively impact the equilibrium or kinetics of the process and include alcohols such as methanol and ethanol; diols such as ethylene glycol; ethers such as diethyl ether, dibutyl ether; esters such as methyl acetate, ethyl acetate and the like; linear, branched and cyclic alkanes such as cyclohexane, methylcyclohexane; fluorinated diluents such as hexafluoroisopropanol, perfluorotetrahydrofuran and perfluorodecalin." (**Ex.1003 at 12:27-13:4**.)
39. The process of claim 36 wherein the reaction stream further comprises a dissolved organics.	"Thus, the dehydrofluorination reaction may preferably use an aqueous solution of at least one base … without the need for a co-solvent or diluent. However, a co-solvent or diluent can be used … to act as a preferred phase for reaction by-products…. Useful co-solvents or diluents include those that are not reactive with or negatively impact the equilibrium or kinetics of the process and include alcohols such as methanol and ethanol; diols such as ethylene glycol; ethers such as diethyl ether, dibutyl ether; esters such as methyl acetate, ethyl acetate and the like; linear, branched and cyclic alkanes such as cyclohexane, methylcyclohexane; fluorinated diluents such as hexafluoroisopropanol, perfluorotetrahydrofuran and perfluorodecalin." (**Ex.1003 at 12:27-13:4**.)

I. Claims 29 and 40 of the '282 Patent are Obvious over Smith in view of Masayuki and Harrison

90. Claim 29 depends from claim 28, and claim 40 depends from claim 37.[5] Both claims recite "wherein the dissolved organics are selected from the group consisting of 1,1,1,2,3,3-hexafluoropropane (HFC-236ea) or 1,1,1,2,3-pentafluoropropane (HFC-245eb)." The claims define the dissolved organics as 236ea or 245eb. As explained above with regard to claims 28 and 39, *Smith* teaches the use of fluorinated diluents in the dehydrohalogenation reaction mixture. Given the solubility of 236ea and 245eb in organic liquids, a POSITA would expect some portion of the organic reagents (236ea and 245eb) in the dehydrofluorination reaction of Smith to be dissolved in the organic co-solvent or diluent component of the reaction stream. Accordingly, in my opinion, the combination of *Smith*, *Masayuki*, and *Harrison* sets forth the elements of claims 29 and 40 in such a manner that a POSITA would have been able to practice the method of claims 29 and 40 with a reasonable expectation of success.

[5] Claim 40, which on its face depends from claim 37, recites "the dissolved organics." However, claim 37 and the claims from which it depends do not introduce the term "dissolved organics." For at least this reason, it is my opinion that the scope of claim 40 is indefinite. For the purposes of my analysis, I have assumed that claim 40 depends from claim 39, which does introduce the term "dissolved organics."

'282 patent claim	Disclosure from *Smith* (Ex. 1003)
29. The process of claim 28 wherein the dissolved organics are selected from the group consisting of 1,1,1,2,3,3-hexafluoropropane (HFC-236ea) or 1,1,1,2,3-pentafluoropropane (HFC-245eb).	"Thus, the dehydrofluorination reaction may preferably use an aqueous solution of at least one base, such as an alkali (or alkaline earth) metal hydroxide, without the need for a co-solvent or diluent. However, a co-solvent or diluent can be used for example to modify the system viscosity… Useful co-solvents or diluents include… fluorinated diluents such as hexafluoroisopropanol, perfluorotetrahydrofuran and perfluorodecalin." (**Ex. 1003 at 12:27-13:4**.)
40. The process of claim 37 wherein the dissolved organics are selected from the group consisting of 1,1,1,2,3,3-hexafluoropropane (HFC-236ea) or 1,1,1,2,3-pentafluoropropane (HFC-245eb).	"Thus, the dehydrofluorination reaction may preferably use an aqueous solution of at least one base, such as an alkali (or alkaline earth) metal hydroxide, without the need for a co-solvent or diluent. However, a co-solvent or diluent can be used for example to modify the system viscosity… Useful co-solvents or diluents include… fluorinated diluents such as hexafluoroisopropanol, perfluorotetrahydrofuran and perfluorodecalin." (**Ex. 1003 at 12:27-13:4**.)

J. Claims 30 and 41 of the '282 Patent are Obvious over Smith in view of Masayuki and Harrison

91. Claim 30 depends from claim 21, and claim 41 depends from claim 36. Both claims recite "…wherein the spent KOH is purified using at least one separation method." *Masayuki* discloses separating aqueous spent alkali metal hydroxide from a lipid phase (e.g., organic catalyst) using a decanter, thereby

purifying the spent alkali metal hydroxide. Ex. 1005 at 10:33-37 and Figure. A decanter is a vessel that allows a mixture of two immiscible liquids (e.g., organic and aqueous phase) to settle and separate by gravity. Once the mixture components have separated, the lighter liquid can be removed leaving the heavier liquid behind for further processing. In *Masayuki*, the organic is removed via conduit 5 and the aqueous phase is left behind and then removed for further processing via conduit 6. Ex. 1005 at 10:37-11:4. *Harrison* teaches separating KOH from KF by converting the KF to CaF_2 and separating the CaF_2 from the KOH after settling, thereby purifying the KOH. Ex. 1006 at 2:14-21. I t would have been obvious to use these well-known separation techniques in the combined process of *Smith*, *Masayuki* and *Harrison*. Indeed, it would be obvious to use any known separation technique to separate components for purification. Further, the '282 patent does not include any disclosure or teaching that leads a POSITA to believe that complete purification or 100% purification is required.

92. Accordingly, in my opinion, the combination of *Smith*, *Masayuki*, and *Harrison* sets forth the elements of claims 30 and 41 in such a manner that a POSITA would have been able to practice the method of claims 30 and 41 with a reasonable expectation of success.

'282 patent claim	Disclosure from *Masayuki* (Ex. 1005)	Disclosure from *Harrison* (Ex. 1006)
30. The process of claim 21 wherein	(**Ex. 1005 Figure, decanter 20 and**	" . . . (b) contacting the solution of step (a) with finely divided

the spent KOH is purified using at least one separation method.	**centrifuge 25**.) "The aqueous phase was extracted via Conduit 4 such that the level of Reactor 19 remained constant and the slightly mixed lipid and aqueous phases (including precipitated sodium chloride) were separated using Decanter 20." (**Ex. 1005 at 10:33-37**.)	high purity lime to thereby obtain a calcium fluoride precipitate in aqueous potassium hydroxide; (c) settling the reaction product of step (b) into two phases comprising an aqueous potassium hydroxide supernatant and an aqueous slurry of calcium fluoride; (d) recovering the aqueous potassium hydroxide supernatant . . ." (**Ex.1006 at 2:14-21**.)
41. The process of claim 36 wherein the spent KOH is purified using at least one separation method.	(**Ex. 1005 Figure, decanter 20 and centrifuge 25**.) "The aqueous phase was extracted via Conduit 4 such that the level of Reactor 19 remained constant and the slightly mixed lipid and aqueous phases (including precipitated sodium chloride) were separated using Decanter 20." (**Ex. 1005 at 10:33-37**.)	" . . . (b) contacting the solution of step (a) with finely divided high purity lime to thereby obtain a calcium fluoride precipitate in aqueous potassium hydroxide; (c) settling the reaction product of step (b) into two phases comprising an aqueous potassium hydroxide supernatant and an aqueous slurry of calcium fluoride; (d) recovering the aqueous potassium hydroxide supernatant . . ." (**Ex.1006 at 2:14-21**.)

K. Claims 31 and 42 of the '282 Patent are Obvious over Smith in view of Masayuki and Harrison

93. Claim 31 depends from claim 30, and claim 42 depends from claim 41. Both claims require that "…the separation method is selected from the group consisting of distillation or phase separation." As explained above, *Masayuki* teaches separation of aqueous spent alkali metal hydroxide from a lipid phase

using decanter 20, and *Harrison* teaches separation of aqueous KOH from solid CaF_2 by settling, both of which are phase separation techniques. Ex.1005 at 10:33-37; Ex. 1006 at 2:14-21. Further, in combining *Masayuki* with *Harrison*, a POSITA would understand that the CaF_2 precipitate produced by conversion of KF to CaF_2 and KOH could be separated from the aqueous mixture comprising KOH by the centrifuge 25 of *Masayuki*, which is also a phase separation technique.

94. Accordingly, in my opinion, the combination of *Smith*, *Masayuki*, and *Harrison* sets forth the elements of claims 31 and 42 in such a manner that a POSITA would have been able to practice the method of claims 31 and 42 with a reasonable expectation of success.

'282 patent claim	Disclosure from *Masayuki* (Ex. 1005)	Disclosure from *Harrison* (Ex. 1006)
31. The process of claim 30 wherein the separation method is selected from the group consisting of distillation or phase separation.	(**Ex. 1005 Figure, decanter 20 and centrifuge 25**.) "The aqueous phase was extracted via Conduit 4 such that the level of Reactor 19 remained constant and the slightly mixed lipid and aqueous phases (including precipitated sodium chloride) were separated using Decanter 20." (**Ex. 1005 at 10:33-37**.)	" . . . (b) contacting the solution of step (a) with finely divided high purity lime to thereby obtain a calcium fluoride precipitate in aqueous potassium hydroxide; (c) settling the reaction product of step (b) into two phases comprising an aqueous potassium hydroxide supernatant and an aqueous slurry of calcium fluoride; (d) recovering the aqueous potassium hydroxide supernatant . . ." (**Ex.1006 at 2:14-21**.)
42. The process of	(**Ex. 1005 Figure,**	" . . . (b) contacting the solution

claim 41 wherein the separation method is selected from the group consisting of distillation or phase separation.	**decanter 20 and centrifuge 25**.) "The aqueous phase was extracted via Conduit 4 such that the level of Reactor 19 remained constant and the slightly mixed lipid and aqueous phases (including precipitated sodium chloride) were separated using Decanter 20." (**Ex. 1005 at 10:33-37**.)	of step (a) with finely divided high purity lime to thereby obtain a calcium fluoride precipitate in aqueous potassium hydroxide; (c) settling the reaction product of step (b) into two phases comprising an aqueous potassium hydroxide supernatant and an aqueous slurry of calcium fluoride; (d) recovering the aqueous potassium hydroxide supernatant . . ." (**Ex.1006 at 2:14-21**.)

L. Claims 32 and 43 of the '282 Patent are Obvious over Smith in view of Masayuki and Harrison

95. Claim 32 depends from claim 21, and claim 43 depends from claim 36. Both claims provide "optionally, concentrating the purified KOH and recycling it back to the dehydrohalogenation reaction." *Masayuki* discloses that "[t]he aqueous phase … was fed into [a] forced circulation-type Enricher 21 via Conduit 6 and concentration [of the aqueous phase] was carried out[.] Recovered sodium hydroxide aqueous solution was returned to Conduit 2 via Conduit 13 and fed back into the reaction." Ex. 1005 at 11:1-16. As explained above, the Decanter 20 is a phase separator that separates the lipid phase (e.g., organic catalyst) from the aqueous phase. *See supra*, ¶ 91. Thus, the aqueous phase that is obtained from the decanter 20 is purified relative to the aqueous phase that was withdrawn from the

reactor and introduced to the decanter 20. The circulation-type enricher 21 concentrates the aqueous phase by evaporating water. In the loop of *Masayuki*, the aqueous phase is heated in heat exchanger 22 and circulated through the enricher 21. Ex. 1005 at 11:6-9. Steam produced by heating is removed from the enricher via conduit 7, thereby concentrating the aqueous phase remaining in the enricher 21. *Id.* at 11:21-23. Precipitated by-product salt is separated and removed by the centrifuge 25. *Id.* at 11:9-14. In *Masayuki*, the salt is NaCl. As discussed above, the salt produced in the dehydrohalogenation process of *Smith* is KF. A POSITA would understand that this salt can be separated and removed from the aqueous phase using the conversion process of *Harrison* whereby KF is converted to KOH and CaF_2, which is precipitated. *See supra*, ¶ 74. Further, a POSITA would understand that the aqueous phase would be introduced to the centrifuge 25, where precipitated CaF_2 would be separated from the aqueous phase in the same way that precipitated NaCl is separated from the aqueous phase in *Masayuki*. The concentrated, purified aqueous phase remaining after the centrifuge 25, which would comprise KOH, would be returned to conduit 2 via conduit 13 and fed back to the reactor for re-use as described in *Masayuki*.

96. Accordingly, in my opinion, the combination of *Smith*, *Masayuki*, and *Harrison* sets forth the elements of claims 32 and 43 in such a manner that a POSITA would have been able to practice the method of claims 32 and 43 with a

reasonable expectation of success.

'282 patent claim	Disclosure from *Masayuki* (Ex. 1005)
32. The process of claim 21 further comprising, optionally, concentrating the purified KOH and recycling it back to the dehydrohalogenation reaction.	"The aqueous phase containing solid sodium chloride from which the lipid phase was removed using Decanter 20 was fed into forced circulation-type Enricher 21 via Conduit 6 and concentration was carried out … As concentration was performed, dissolved sodium chloride precipitated out, but said aqueous phase was extracted via Conduit 8, directed into Slurry Tank 24 via Conduit 11 and fed into Centrifuge 25 where precipitated sodium chloride was separated out … Recovered sodium hydroxide aqueous solution was returned to Conduit 2 via Conduit 13 and fed back into the reaction." (**Ex. 1005 at 11:1-16**.)
43. The process of claim 36 further comprising, optionally, concentrating the purified KOH and recycling it back to the dehydrohalogenation reaction.	"The aqueous phase containing solid sodium chloride from which the lipid phase was removed using Decanter 20 was fed into forced circulation-type Enricher 21 via Conduit 6 and concentration was carried out … As concentration was performed, dissolved sodium chloride precipitated out, but said aqueous phase was extracted via Conduit 8, directed into Slurry Tank 24 via Conduit 11 and fed into Centrifuge 25 where precipitated sodium chloride was separated out … Recovered sodium hydroxide aqueous solution was returned to Conduit 2 via Conduit 13 and fed back into the reaction." (**Ex. 1005 at 11:1-16**.)

M. Claims 33 and 44 of the '282 Patent are Obvious over Smith in view of Masayuki and Harrison

97. Claim 33 depends from claim 21, and claim 44 depends from claim 36. Both claims specify that the reaction stream further comprises KF. *Smith* teaches dehydrofluorination of 245eb using KOH to produce 1234yf. Ex. 1003 at 1:23-2:2, 11:9-15. A POSITA would understand that a by-product of the dehydrofluorination reaction of 245eb with KOH is KF and that the reaction stream therefore comprises KF. *See*, Ex. 1010 at 13:16-22. For example, *Mukhopadhyay*, which published May 18, 2007, and is therefore prior art to the '282 patent describes an aqueous, base-mediated dehydrofluorination reaction where 245eb is converted to 1234yf using aqueous KOH. *Mukhopadhyay* states that "[o]ne preferred reaction step may be described … by the following reaction equation in connection with embodiments in which the compound of formula (I) is 1,1,1,2,3 pentafluoropropane [245eb] and the dehydrohalogenating agent is potassium hydroxide (KOH): CF_3CHFCH_2F [245eb] + KOH → $CF_3CF{=}CH_2$ [1234yf] + ***KF*** + H_2O". Ex. 1010 at 13:16-22 (emphasis added). Accordingly, in my opinion, the combination of *Smith*, *Masayuki*, and *Harrison* sets forth the elements of claims 33 and 44 in such a manner that a POSITA would have been able to practice the method of claims 33 and 44 with a reasonable expectation of success.

'282 patent	Disclosure from *Smith* (Ex. 1003)

claim	
33. The process of claim 21 wherein the reaction stream further comprises KF.	"The subject invention addresses the deficiencies of the known methods for preparing 1234yf by providing a process for the preparation of 1234yf comprising …(b) dehydrofluorinating 236ea to produce 1,2,3,3,3-pentafluoropropene (referred to hereinafter as 1225ye); … and (d) dehydrofluorinating 245eb to produce 1234yf ." (**Ex. 1003 at 1:23-2:2**.) "Another preferred method of effecting the dehydrofluorination in steps (b) and (d) is by contacting 236ea and/or 245eb with a base. Preferably, the base is a metal hydroxide …, e.g. an alkali or alkaline earth metal hydroxide or amide). … the term "alkali metal hydroxide" [refers] to a compound or mixture of compounds selected from lithium hydroxide, sodium hydroxide, potassium hydroxide, rubidium hydroxide and caesium hydroxide." (**Ex. 1003 at 11: 9-15**.)
44. The process of claim 36 wherein the reaction stream further comprises KF.	"The subject invention addresses the deficiencies of the known methods for preparing 1234yf by providing a process for the preparation of 1234yf comprising …(b) dehydrofluorinating 236ea to produce 1,2,3,3,3-pentafluoropropene (referred to hereinafter as 1225ye); … and (d) dehydrofluorinating 245eb to produce 1234yf ." (**Ex. 1003 at 1:23-2:2**.) "Another preferred method of effecting the dehydrofluorination in steps (b) and (d) is by contacting 236ea and/or 245eb with a base. Preferably, the base is a metal hydroxide …, e.g. an alkali or alkaline earth metal hydroxide or amide). … the term "alkali metal hydroxide" [refers] to a compound or mixture of compounds selected from lithium hydroxide, sodium hydroxide, potassium hydroxide, rubidium hydroxide and caesium hydroxide." (**Ex. 1003 at 11: 9-15**.)

N. Claim 34 of the '282 Patent is Obvious over Smith in view of Masayuki and Harrison

98. Claim 34 depends from claim 33 and recites converting KF to KOH in the presence of $Ca(OH)_2$. As discussed above, *Harrison* teaches that KF in the

aqueous mixture of KOH and KF is converted to KOH by treating the mixture with $Ca(OH)_2$. Ex. 1006 at 2:14-16, 3:6-10. Accordingly, in my opinion, the combination of *Smith*, *Masayuki*, and *Harrison* sets forth the elements of claim 34 in such a manner that a POSITA would have been able to practice the method of claim 34 with a reasonable expectation of success.

'282 patent claim	Disclosure from *Harrison* (Ex. 1006)
34. The process of claim 33 further comprising converting KF to KOH in the presence of $Ca(OH)_2$.	"… (b) contacting [an aqueous solution of potassium fluoride and potassium hydroxide] with finely divided high purity lime to thereby obtain a calcium fluoride precipitate in aqueous potassium hydroxide." (**Ex. 1006 at 2:14-16**.) "The basic potassium fluoride solution is then mixed with solid hydrated (slaked) lime in a stirred vessel where this calcium hydroxide [$Ca(OH)_2$] reacts to form the calcium fluoride precipitate and regenerate the potassium hydroxide." (**Ex. 1006 at 3:6-10**.)

O. Claims 35 and 46 of the '282 Patent are Obvious over Smith in view of Masayuki and Harrison

99. Claim 35 depends from claim 34, and claim 46 depends from claim 36. Claim 35 recites optionally, concentrating the converted KOH and recycling it back to the dehydrohalogenation reaction, and claim 46 recites converting KF to KOH in the presence of $Ca(OH)_2$, optionally, concentrating the converted KOH and recycling it back to the dehydrohalogenation reaction. I understand that the step of concentrating the converted KOH is not required by claims 35 and 46 because it is an "optional" step. As discussed above, *Harrison* teaches that KF in

the aqueous mixture of KOH and KF is converted to KOH by treating the mixture with $Ca(OH)_2$. Ex. 1006 at 2:14-16, 3:6-10. As also discussed above, the conversion step of *Harrison* can be implemented in the slurry tank 24 of *Masayuki* without disruption to any of the other processing steps in *Masayuki*. *See supra*, ¶¶ 74, 75. In *Masayuki*, the centrifuge 25 separates out the precipitated solid (which would be CaF_2 when *Masayuki* is combined with *Smith* and *Harrison*) from the aqueous phase containing concentrated alkali metal hydroxide (KOH). The aqueous phase containing concentrated, recovered KOH is returned to conduit 2 via conduit 13 and recycled to the dehydrofluorination reaction. *See supra*, ¶¶ 74, 75.

100. Accordingly, in my opinion, the combination of *Smith*, *Masayuki*, and *Harrison* sets forth the elements of claims 35 and 46 in such a manner that a POSITA would have been able to practice the method of claims 35 and 46 with a reasonable expectation of success.

'282 patent claim	Disclosure from *Masayuki* (Ex. 1005)	Disclosure from *Harrison* (Ex. 1006)
35. The process of claim 34 further comprising, optionally, concentrating the converted KOH and recycling it back to the dehydrohalogenation reaction.	"The aqueous phase containing solid sodium chloride from which the lipid phase was removed using Decanter 20 was fed into forced circulation-type Enricher 21 via Conduit 6 and concentration was carried out … As concentration was performed, dissolved sodium chloride precipitated out, but	"… (b) contacting [an aqueous solution of potassium fluoride and potassium hydroxide] with finely divided high purity lime to thereby obtain a calcium fluoride precipitate in aqueous potassium hydroxide." **(Ex. 1006 at 2:14-16.)**

	said aqueous phase was extracted via Conduit 8, directed into Slurry Tank 24 via Conduit 11 and fed into Centrifuge 25 where precipitated sodium chloride was separated out …. Recovered sodium hydroxide aqueous solution was returned to Conduit 2 via Conduit 13 and fed back into the reaction." (**Ex. 1005 at 11:1-16**.)	"The basic potassium fluoride solution is then mixed with solid hydrated (slaked) lime in a stirred vessel where this calcium hydroxide [Ca(OH)2] reacts to form the calcium fluoride precipitate and regenerate the potassium hydroxide." (**Ex. 1006 at 3:6-10.**)
46. The process of claim 36 further comprising converting KF to KOH in the presence of $Ca(OH)_2$, optionally, concentrating the KOH and recycling it back to the dehydrohalogenation reaction.	"The aqueous phase containing solid sodium chloride from which the lipid phase was removed using Decanter 20 was fed into forced circulation-type Enricher 21 via Conduit 6 and concentration was carried out … As concentration was performed, dissolved sodium chloride precipitated out, but said aqueous phase was extracted via Conduit 8, directed into Slurry Tank 24 via Conduit 11 and fed into Centrifuge 25 where precipitated sodium chloride was separated out …. Recovered sodium hydroxide aqueous solution was returned to Conduit 2 via Conduit 13 and fed back into the reaction." (**Ex. 1005 at 11:1-16**.)	"… (b) contacting [an aqueous solution of potassium fluoride and potassium hydroxide] with finely divided high purity lime to thereby obtain a calcium fluoride precipitate in aqueous potassium hydroxide." (**Ex. 1006 at 2:14-16.)** "The basic potassium fluoride solution is then mixed with solid hydrated (slaked) lime in a stirred vessel where this calcium hydroxide [Ca(OH)2] reacts to form the calcium fluoride precipitate and regenerate the potassium hydroxide." (**Ex. 1006 at 3:6-10.**)

P. Claim 45 of the '282 Patent is Obvious over Smith in view of Masayuki and Harrison

101. Claim 45 depends from claim 44 and specifies "…comprising purifying the

KF from the reaction stream." Based on my review of the specification of the '282 patent, it is my opinion that the disclosure of the '282 patent would not enable a POSITA to purify KF from the reaction stream without undue experimentation. Therefore, it is my opinion that a POSITA, reading claim 45 in view of the entire disclosure of the '282 patent would understand this term to refer to the removal of KF from the spent KOH, e.g., by conversion of KF to KOH and CaF_2 using $Ca(OH)_2$. If interpreted otherwise, it is my opinion that claim 45 is not enabled. As explained above, *Harrison* teaches converting KF to KOH using $Ca(OH)_2$. Ex. 1006 at 2:14-16, 3:6-10. Accordingly, in my opinion, the combination of *Smith*, *Masayuki*, and *Harrison* sets forth the elements of claim 45 (if purifying KF means converting KF to KOH) in such a manner that a POSITA would have been able to practice the method of claim 45 with a reasonable expectation of success.

'282 patent claim	Disclosure from *Harrison* (Ex. 1006)
45. The process of claim 44 further comprising purifying KF from the reaction stream.	"…(b) contacting [an aqueous solution of potassium fluoride and potassium hydroxide] with finely divided high purity lime to thereby obtain a calcium fluoride precipitate in aqueous potassium hydroxide." (**Ex. 1006 at 2:14-16**.) "The basic potassium fluoride solution is then mixed with solid hydrated (slaked) lime in a stirred vessel where this calcium hydroxide [$Ca(OH)_2$] reacts to form the calcium fluoride precipitate and regenerate the potassium hydroxide." (**Ex. 1006 at 3:6-10**.)

Q. Claim 1 of the '282 Patent is Obvious over Smith in view of Masayuki and Harrison

102. Claim 1 of the '282 patent recites: (a) hydrogenating a starting material including alkene(s) with a reducing agent to produce an intermediate product stream, (b) optionally separating the intermediate stream into a plurality of intermediate product streams, (c) dehydrofluorinating, in the presence of a DHA, at least a portion of the intermediate process stream(s) to produce 1225ye and at least one additional alkene having a lower degree of fluorination (e.g., 1234yf), (d) withdrawing from a dehydrofluorinated product stream a product reaction stream comprising spent DHA, and (e) recovering spent DHA. As explained below, *Smith* describes steps (a)-(c), *Masayuki* describes step (d), and the combination of *Masayuki* and *Harrison* describes step (e). As explained above for claim 21, it would have been obvious to modify the dehydrohalogenation process of *Smith* to recover and recycle DHA using the "withdrawing" step and the "recovering" step as taught in the combination *Masayuki* and *Harrison*. To achieve a more efficient and cost effective process than the one disclosed in *Smith*, a POSITA would look to analogous, base-mediated dehydrohalogenation processes for suggestions of how to recover and/or recycle unreacted KOH and by-product salt of the KOH (e.g., KF) formed in the reaction. *See supra*, ¶ 68. *Masayuki* teaches recovering

and recycling unreacted alkali metal hydroxide in one such analogous, base-mediated dehydrohalogenation process. To make the dehydrohalogenation process of *Smith* even more efficient and cost effective, a POSITA would be motivated to increase the amount of DHA recovered and recycled to the dehydrohalogenation reaction and to make productive use of the by-product salt. *See supra*, ¶ 68. *Harrison* teaches a method for converting by-product salt (KF) back to DHA (KOH), which would enable such increase in recovery and recycle of DHA. A POSITA would have been motivated to apply the combined teaching of *Masayuki* and *Harrison* to the dehydrohalogenation process of *Smith* to maximize the amount of DHA recovered and recycled to the dehydrohalogenation reaction, and to make productive use of the by-product(s) formed in the reaction, thereby reducing operating costs and increasing process efficiency and would have had a reasonable expectation of success in making such a combination. *See supra*, ¶¶ 68, 77.

103. *Smith* describes steps (a)-(c) of claim 1. *Smith* discloses hydrogenating a starting material including alkene(s) with a reducing agent to produce an intermediate stream (step (a) of claim 1). Specifically, *Smith* describes a process for preparing fluorinated olefins that includes hydrogenating HFP with hydrogen (a reducing agent) to provide 236ea (step (a) of *Smith*). Ex. 1003 at 1:23-2:2. *Smith* further describes hydrogenating 1225ye with hydrogen to yield 245eb (step (c) of *Smith*). *Id.* Both HFP and 1225ye meet the requirements of Formula I of claim 1

of the ’282 patent. The explanation for HFP is as follows: Formula I is $(CX_nY_{3-n})(CR^1_aR^2_b)_zCX=CH_mX_{2-m}$. The formula for HFP is $CF_3CF=CF_2$. For HFP to meet the requirements of Formula I, X is F, n is 3, m is 0, and z is 0. With these values of X, n, m, and z, Formula I becomes $(CF_3Y_{3-3})(CR^1_aR^2_b)_0CF=CH_0F_{2-0}$ or $CF_3CF=CF_2$ (HFP). As can be seen, when n is 3 and z is 0, the values of Y, R^1, R^2, a, and b need not be defined because they are not present. The explanation for 1225ye is as follows: Formula I is $(CX_nY_{3-n})(CR^1_aR^2_b)_zCX=CH_mX_{2-m}$. The formula for 1225ye is $CF_3CF=CHF$. For 1225ye to meet the requirements of Formula I, X is F, n is 3, m is 1, and z is 0. With these values of X, n, m, and z, Formula I becomes $(CF_3Y_{3-3})(CR^1_aR^2_b)_0CF=CH_1F_{2-1}$ or $CF_3CF=CHF$ (1225ye). As can be seen, when n is 3 and z is 0, the values of Y, R^1, R^2, a, and b need not be defined because they are not present. Likewise, both 236ea and 245eb meet the requirements of Formula II of claim 1 of the ’282 patent (For 236ea, X is F, n is 3, m is 0, and z is 0; for 245eb, X is F, n is 3, m is 1, and z is 0.). Therefore, *Smith* discloses step (a) of claim 1 of the ’282 patent.

104. Although I understand that step (b) is not required by claim 1 of the ’282 patent because it is an optional step, *Smith* further describes separating the intermediate stream into a plurality of intermediate product streams (step (b) of claim 1). *Smith* describes that hydrogenation of HFP and 1225ye may be conducted simultaneously in the same reactor to produce both 236ea and 245eb.

Ex.1003 at 2:29-3:5. *Smith* further describes optionally separating 236ea and 245eb after hydrogenation and before dehydrofluorination. 236ea and 245eb may be separated from each other (e.g., by distillation) before being fed into separate dehydrofluorination reactors for carrying out steps (b) and (d) of *Smith*. *Id.* at 3:5-7. *Smith* further describes an alkane recycle stream wherein a diluent gas stream "…can be a gas such as … one or both of the products from steps (a) and (c), 245eb or 236ea." Ex. 1003 at 3:15-20. Therefore, *Smith* also discloses step (b) of the '282 patent.

105. *Smith* further describes dehydrofluorinating, in the presence of a DHA, at least a portion of the intermediate process stream(s) to produce 1225ye and at least one additional alkene having a lower degree of fluorination than the compound of Formula I (e.g., 1234yf) (step (c) of claim 1). *Smith* describes dehydrofluorinating 236ea and 245eb with a DHA (e.g., a base) to produce 1225ye and 1234yf, respectively (steps (b) and (d) of *Smith*). Ex.1003 at 1:23-2:2, 11:9-10. Dehydrofluorination of 236ea and 245eb may be carried out in separate reactors as mentioned above or simultaneously in the same reactor. For example, separate feeds may be fed to a single reactor in which steps (b) and (d) of *Smith* are carried out simultaneously. *Id.* at 3:4-14. Accordingly, *Smith* discloses steps (a)-(c) of claim 1.

106. As explained above for claim 21, *Masayuki* teaches withdrawing from a

dehydrohalogenated product stream a product reaction stream comprising spent DHA. *See supra*, ¶ 71. As also explained above, a POSITA would understand the withdrawing limitation of claim 1 to encompass "taking out or removing" from a reactor a product stream including dehydrofluorinated product and a separate stream including spent KOH. *Masayuki* describes a base-mediated dehydrohalogenation process, in particular, dehydrochlorinating 3,4-dichloro-butene-l using an aqueous solution of alkali metal hydroxide (e.g., NaOH or KOH) to produce a gas phase mixture comprising chloroprene and a water phase comprising an aqueous solution of alkali metal hydroxide and alkali metal halide (e.g., NaCl or KCl) and solid alkali metal halide. Ex. 1005 at 6:14-33, 6:37-7:2. In an example of the process described in *Masayuki*, the gas phase mixture and the water phase are removed from the reactor separately. *Id*. at 10:33-34 (water phase) and 6:19-23, 11:24-25 (gas phase mixture). The aqueous phase containing unreacted DHA and by-product salt (NaCl) is withdrawn from the reactor 19 via conduit 4 for additional processing. Ex. 1005 at 10:33-35. Accordingly, *Masayuki* describes withdrawing from a dehydrohalogenated product stream a product reaction stream comprising spent DHA. Applying the withdrawing step of *Masayuki* to the dehydrofluorination process of *Smith* results in withdrawing from a dehydrofluorinated product stream a product reaction stream comprising spent DHA, as recited in step (d) of claim 1. *See supra*, ¶¶ 71-72.

107. As explained above for claim 21, the combination of *Masayuki* and *Harrison* teaches recovering spent DHA (step (e) of claim 1). As also explained above, the recovering and recycling process of *Masayuki* is improved by the conversion step of *Harrison* because it enables recovery and recycling of more DHA and because it utilizes the KF by-product. Thus, a POSITA would have been motivated to apply the method of *Harrison* to the dehydrofluorination process of *Smith*, as modified by *Masayuki*, in order to increase the recovery of DHA and would have had a reasonable expectation of success in doing so. *See supra*, ¶¶ 73-77.

108. A POSITA would have understood that the various aspects of *Smith*, *Masayuki*, and *Harrison* would have suggested to a POSITA to (a) hydrogenate a starting material including alkene(s) with a reducing agent to produce an intermediate stream, (b) optionally separate the intermediate stream into a plurality of intermediate product streams, (c) dehydrofluorinate, in the presence of a DHA, at least a portion of the intermediate process stream(s) to produce 1225ye and at least one additional alkene having a lower degree of fluorination (e.g., 1234yf), (d) withdraw from a dehydrofluorinated product stream a product reaction stream comprising spent DHA, and (e) recover spent DHA. Accordingly, in my opinion, the combination of *Smith*, *Masayuki*, and *Harrison* sets forth the elements of claim 1 in such a manner that a POSITA would have been able to practice the method of claim 1 with a reasonable expectation of success.

'282 patent claim	Disclosure from *Smith* (Ex. 1003)
1. A method for producing at least one fluorinated olefin comprising: a. hydrogenating a starting material stream comprising at least one alkene according to Formula (I): $(CX_nY_{3-n})(CR^1_aR^2_b)_zCX=CH_mX_{2-m}$ (I) by contacting said starting material with a reducing agent to produce an intermediate product stream comprising at least one alkane according to Formula (II): $(CX_nY_{3-n})(CR^1_aR^2_b)_zCHXCH_{m+1}X_{2-m}$ (II) where: each X is independently Cl, F, I or Br, provided that at least two Xs are F; each Y is independently H, Cl, F, I or Br; each R^1 is independently H, Cl, F, I, Br or unsubstituted or halogen substituted methyl or ethyl radical; each R_2 is independently H, Cl, F, I, Br or unsubstituted or halogen substituted methyl or ethyl radical; n is 1, 2 or 3; a and b are each 0, 1 or 2, provided that a+b=2; m is 0, 1 or 2; and z is 0, 1, 2 or 3;	"The subject invention addresses the deficiencies of the known methods for preparing 1234yf by providing a process for the preparation of 1234yf comprising (a) contacting 1,1,2,3,3,3-hexafluoropropene (referred to hereinafter as 1216 or HFP) with hydrogen in the presence of a hydrogenation catalyst to produce 1,1,2,3,3,3-hexafluoropropane (referred to hereinafter as 236ea); … (c) contacting 1225ye with hydrogen in the presence of a hydrogenation catalyst to produce 1,2,3,3,3-pentafluoropropane (referred to hereinafter as 245eb)." (**Ex. 1003 at 1:23-2:2**.)
b. optionally, separating said intermediate product stream into a plurality of intermediate product streams, said plurality of intermediate product streams comprising two or more streams selected from the group consisting of a first stream rich in at least a first alkane according to Formula II, a seconds stream rich in at least a second alkane according to Formula II, and an alkane recycle stream;	"In a further reaction topology, steps (a) and (c) of the process of the invention may be carried out simultaneously in the same reactor. … The product of the reaction wherein steps (a) and (c) are conducted simultaneously in the same reactor comprises 236ea and 245eb." (**Ex. 1003 at 2:29-3:5**.) "These may be separated from each other (e.g. by distillation) before being fed into separate dehydrofluorination

	reactors for carrying out steps (b) and (d)." (**Ex. 1003 at 3:5-7**.) "[T]he exothermic hydrogenation reactions of step (a) and/or (c) … may be controlled by the use of a diluent gas stream. ... The diluent gas stream can be a gas such as … one or both of the products from steps (a) and (c), 245eb or 236ea." (**Ex. 1003 at 3:15-20**.)
c. dehydrofluorinating, in the presence of a dehydrohalogenating agent, at least a portion of said intermediate process stream from step (a) or said plurality of intermediate process streams of step (b) to produce an alkene product stream comprising 1,1,1,2,3-pentafluoropropene [1,2,3,3,3-pentafluoropropene (1225ye)] and at least one additional alkene having a lower degree of fluorine substitution compared to the degree of fluorination of the compound of formula (I); and	"The subject invention addresses the deficiencies of the known methods for preparing 1234yf by providing a process for the preparation of 1234yf comprising …(b) dehydrofluorinating 236ea to produce 1,2,3,3,3-pentafluoropropene (referred to hereinafter as 1225ye); … and (d) dehydrofluorinating 245eb to produce 1234yf." (**Ex. 1003 at 1:23-2:2**.) "Another preferred method of effecting the dehydrofluorination … is by contacting 236ea and/or 245eb with a base." (**Ex. 1003 at 11:9-10**.) "The product of the reaction wherein steps (a) and (c) are conducted simultaneously in the same reactor comprises both 236ea and 245eb. These may be separated from each other (e.g. by distillation) before being fed into separate dehydrofluorination reactors for carrying out steps (b) and (d). Alternatively, … a combined stream of 236ea and 245eb may be fed to a single reactor. Thus, dehydrofluorination steps (b) and (d) may be carried out simultaneously in

	the same reactor. … Of course, separate feeds of 236ea and 245eb originating from separate hydrogenation reactors may be fed to a single dehydrofluorination reactor in which steps (b) and (d) are carried out simultaneously." (**Ex. 1003 at 3:4-14.**)
Claim 1 (cont.)	Disclosure from *Masayuki* (Ex. 1005)
d. withdrawing from a dehydrofluorinated product stream a product reaction stream comprising spent dehydrohalogenating agent; and	(**Ex. 1005 Figure, stream 4**.) "The aqueous phase was extracted via Conduit 4 such that the level of Reactor 19 remained constant" (**Ex.1005 at 10:33-35**.) "[A] mixture containing chloroprene, unreacted 3,4-dichloro-butene-1 and water produced by performing a reaction at a temperature of 20 – 100°C is removed in a gas phase via evaporation without reflux of said mixture into the reaction system." (**Ex. 1005 at 6:19-23**.)

Claim 1 (cont.)	Disclosure from *Masayuki* (Ex. 1005)	Disclosure from *Harrison* (Ex. 1006)
e. recovering spent dehydrohalogenating agent.	(**Ex. 1005 Figure, decanter 20, enricher 21, centrifuge 25**.) "The aqueous phase was extracted via Conduit 4 such that the level of Reactor 19 remained constant and the lightly mixed lipid and aqueous phases (including precipitated sodium chloride) were separated using Decanter 20, after	" . . . (b) contacting [an aqueous solution of potassium fluoride and potassium hydroxide] with finely divided high purity lime to thereby obtain a calcium fluoride precipitate in aqueous potassium hydroxide (c) settling the reaction product of step (b) into two phases comprising an aqueous potassium hydroxide supernatant and an aqueous slurry of calcium fluoride;

	which the lipid phase was returned to the reactor via Conduit 5." (**Ex. 1005 at 10:33-11:1**.) "The aqueous phase … was fed into a forced circulation-type Enricher 21 via Conduit 6 and concentration was carried out … After passing through Conduit 9 from Conduit 8, the aqueous phase was heated in Heat Exchanger 22 after which it was circulated in Enricher 21 via Conduit 10." (**Ex. 1005 at 11:1-9**.) "As concentration was performed, dissolved sodium chloride precipitated out, but said aqueous phase was extracted via Conduit 8, directed into Slurry Tank 24 via Conduit 11 and fed into Centrifuge 25 where precipitated sodium chloride was separated out and also discarded via Conduit 12." (**Ex.1005 at 11:9-14**.)	(d) recovering the aqueous potassium hydroxide supernatant . . ." (**Ex.1006 at 2:14-21**.) "The basic potassium fluoride solution is then mixed with solid hydrated (slaked) lime in a stirred vessel where this calcium hydroxide [$Ca(OH)_2$] reacts to form the calcium fluoride precipitate and regenerate the potassium hydroxide." (**Ex. 1006 at 3:6-10**.)

R. Claims 2-6 of the '282 Patent are Obvious over Smith in View of Masayuki and Harrison

109. Claim 2 depends from claim 1 and further defines "the additional alkene"

produced in step (c) as a compound of Formula (III)), $(CX_nY_{3-n})(CR^1_aR^2_b)_zCX{=}CH_{m+1}X_{1-m}$, where each of X, Y, R^1, R^2, n, a, and b is the same value as in formula (I) and m is 0 or 1. Claims 3-6 further define Formula (III), specifying that Z is 0 (claim 3), m is 0 or 1 (claim 4), n is 3 (claim 5), and X is F (claim 6). As discussed above in connection with claim 1, formula (I) reads on the disclosure of HFP and 1225ye in *Smith* when X is F, n is 3, and z is 0. When n is 3, the first part of formula III, (CX_nY_{3-n}), becomes CX_3Y_{3-3} or CX_3, so the value of Y need not be defined when n is 3. When z is 0, the second part of formula III, $(CR^1_aR^2_b)_z$, becomes $(CR^1_aR^2_b)_0$ and thus is no longer present, so the values of R^1, R^2, a, and b need not be defined when z is 0. *See supra*, ¶ 103. Thus, when the alkene according to formula (I) is understood to be HFP or 1225ye, as disclosed in *Smith*, claim 2 requires that the additional alkene is a compound of Formula (III), $(CX_nY_{3-n})(CR^1_aR^2_b)_zCX{=}CH_{m+1}X_{1-m}$, where X is F, n is 3, m is 0 or 1, and Y, R^1, R^2, a, b, and z can take any value permitted by formula (I). *Smith* discloses dehydrofluorinating 236ea and 245eb to produce 1225ye and 1234yf, respectively (steps (b) and (d) of *Smith*). Ex.1003 at 1:23-2:2. Formula (III) reads on 1234yf (CF_3-$CF{=}CH_2$), when X is F, n is 3, z is 0, and m is 1. As such, 1234yf meets the requirements of formula (III), as defined in claims 2-6. Accordingly, in my opinion, the combination of *Smith*, *Masayuki*, and *Harrison* sets forth the elements of claims 2-6 in such a manner that a POSITA would have been able to practice the

method of claims 2-6 with a reasonable expectation of success.

'282 patent claim	Disclosure from *Smith* (Ex. 1003)
2. The method of claim 1 wherein said additional alkene is a compound according to formula (III): $(CX_nY_{3-n})(CR^1_aR^2_b)_zCX=CH_{m+1}X_{1-m}$ (III) where each of X, Y, R^1, R^2, n, a, and b is the same value as in formula (I) and m is 0 or 1. 3. The method of claim 2 wherein Z is 0. 4. The method of claim 3 wherein m is 0 or 1 5. The method of claim 4 wherein said n is 3. 6. The method of claim 5 wherein X is F.	"The subject invention addresses the deficiencies of the known methods for preparing 1234yf by providing a process for the preparation of 1234yf comprising … (d) dehydrofluorinating 245eb to produce 1234yf." (**Ex. 1003 at 1:23-2:2**.)

S. Claim 7 of the '282 Patent is Obvious over Smith in View of Masayuki and Harrison

110. Claim 7 depends from claim 1 and further requires that said reducing agent is H_2. *Smith* describes using hydrogen as the reducing agent in the hydrogenation reactions of steps (a) and (c). Ex. 1003 at 1:23-2:2. Accordingly, in my opinion, the combination of *Smith*, *Masayuki*, and *Harrison* sets forth the elements of claim 7 in such a manner that a POSITA would have been able to practice the method of claim 7 with a reasonable expectation of success.

'282 patent claim	Disclosure from *Smith* (Ex. 1003)
7. The method of claim 1 wherein said reducing agent is H_2.	"The subject invention addresses the deficiencies of the known methods for preparing 1234yf by providing a process for the preparation of 1234yf comprising (a) contacting 1,1,2,3,3,3- hexafluoropropene (referred to hereinafter as 1216 or HFP) with hydrogen in the presence of a

	hydrogenation catalyst to produce 1,1,2,3,3,3-hexafluoropropane (referred to hereinafter as 236ea) … (c) contacting 1225ye with hydrogen in the presence of a hydrogenation catalyst to produce 1,2,3,3,3-pentafluoropropane (referred to hereinafter as 245eb)." (**Ex. 1003 at 1:23-2:2**.)

T. Claim 8 of the '282 Patent is Obvious over Smith in View of Masayuki and Harrison

111. Claim 8 depends from claim 1 and further requires that the starting material stream comprises hexafluoropropylene [HFP] and said additional alkene is 2,3,3,3-tetrafluoropropene [1234yf]. *Smith* describes a process for producing 1234yf that involves hydrogenation of 1,1,2,3,3,3-hexafluoropropene [HFP] and dehydrohalogenation of 245eb to produce 1234yf. Ex. 1003 at 1:23-2:2. One of ordinary skill in the art would understand that 1,1,2,3,3,3-hexafluoropropene (HFP) is a synonym for hexafluoropropylene. Specifically, a POSITA would understand that the "-ene" and "-ylene" suffixes are merely alternative methods of naming alkenes (e.g., "ethene" is a synonym for "ethylene"; "propene" is a synonym for "propylene"; etc.). Similarly, "1,1,2,3,3,3-hexafluoropropene" is a synonym for "1,1,2,3,3,3-hexafluoropropylene." Further, a POSITA would understand that 1,1,2,3,3,3-hexafluoropropylene is a fully fluorinated propylene derivative, and therefore it is unnecessary to specify the positions of the fluorine atoms. In other words, 1,1,2,3,3,3-hexafluoropropylene can be described unambiguously as "hexafluoropropylene." Accordingly, in my opinion, the

combination of *Smith*, *Masayuki*, and *Harrison* sets forth the elements of claim 8 in such a manner that a POSITA would have been able to practice the method of claim 8 with a reasonable expectation of success.

'282 patent claim	Disclosure from *Smith* (Ex. 1003)
8. The method of claim 1 wherein said starting material stream comprises hexafluoropropylene and said additional alkene is 2,3,3,3-tetrafluoropropene [1234yf].	"The subject invention addresses the deficiencies of the known methods for preparing 1234yf by providing a process for the preparation of 1234yf comprising (a) contacting 1,1,2,3,3,3-hexafluoropropene (HFP) with hydrogen in the presence of a hydrogenation catalyst to produce 1,1,2,3,3,3-hexafluoropropane (236ea); … and (d) dehydrofluorinating 245eb to produce 1234yf." (**Ex. 1003 at 1:23-2:2**.)

U. Claim 9 of the '282 Patent is Obvious over Smith in View of Masayuki and Harrison

112. Claim 9 depends from claim 1 and further requires that the DHA is selected from the group consisting of KOH, NaOH, $Ca(OH)_2$, LiOH, $Mg(OH)_2$, CaO, and combinations thereof. *Smith* describes using KOH as a DHA. Ex. 1003 at 11: 9-15. Accordingly, in my opinion, the combination of *Smith*, *Masayuki*, and *Harrison* sets forth the elements of claim 9 in such a manner that a POSITA would have been able to practice the method of claim 9 with a reasonable expectation of success.

'282 patent claim	Disclosure from *Smith* (Ex. 1003)
9. The method of claim 1 wherein the dehydrohalogenating agent is selected from	"Another preferred method of effecting the dehydrofluorination in steps (b) and (d) is by contacting 236ea and/or 245eb with a base. Preferably, the base is a metal hydroxide …, e.g. an alkali or alkaline earth metal

the group consisting of KOH, NaOH, $Ca(OH)_2$, LiOH, $Mg(OH)_2$, CaO, and combinations thereof.	hydroxide[. T]he term "alkali metal hydroxide" [refers] to a compound or mixture of compounds selected from lithium hydroxide, sodium hydroxide, potassium hydroxide, rubidium hydroxide and caesium hydroxide." (**Ex. 1003 at 11: 9-15**.)

V. Claim 10 of the '282 Patent is Obvious over Smith in View of Masayuki and Harrison

113. Independent claim 10 recites a method of producing 1234yf comprising (a) hydrogenating HFP by contacting it with a reducing agent in a hydrogenation reactor to produce 245eb or 236ea, (b) dehydrofluorinating, in the presence of a DHA, 245eb or 236ea in a dehydrofluorination reactor to produce a product stream comprising 1234yf or 1225ye, (c) withdrawing a second product stream including spent DHA from the product stream, and (d) recovering spent DHA. As explained below, *Smith* discloses steps (a) and (b), *Masayuki* teaches step (c), and the combination of *Masayuki* and *Harrison* teaches step (d).

114. As explained above for claim 1, it would have been obvious to modify the dehydrohalogenation process of *Smith* to recover and recycle DHA using the "withdrawing" step and the "recovering" step as taught in the combination of *Masayuki* and *Harrison*. A POSITA would have been motivated to apply the combined teachings of *Masayuki* and *Harrison* to the dehydrohalogenation process of *Smith* to maximize the amount of DHA recovered and recycled to the dehydrohalogenation process, and to make productive use of the by-product(s)

formed in the reaction, thereby reducing operating costs and increasing process efficiency and would have had a reasonable expectation of success in making such a combination. *See supra*, ¶ 102.

115. *Smith* describes steps (a) and (b) of claim 10. *Smith* describes hydrogenating a starting material stream comprising HFP by contacting the starting material stream with a reducing agent in a hydrogenation reactor to produce an intermediate stream comprising 245eb or 236ea (step (a) of claim 10). Specifically, *Smith* describes a process for preparing fluorinated olefins including hydrogenating HFP with hydrogen (a reducing agent) to provide 236ea. Ex. 1003 at 1:23-2:2. *Smith* further describes hydrogenating 1225ye with hydrogen to yield 245eb. *Id.* Hydrogenation of HFP and 1225ye may be carried out separately or simultaneously in the same reactor to produce both 236ea and 245eb simultaneously. *Id.* at 2:16-17, 2:29-3:5.

116. *Smith* further describes dehydrofluorinating, in the presence of a DHA, 245eb or 236ea in a dehydrofluorination reactor to produce a product stream comprising 1234yf or 1225ye (step (b) of claim 10). *Smith* describes dehydrofluorinating 236ea and 245eb using a DHA (e.g., a base) to produce 1225ye and 1234yf, respectively (steps b and d of *Smith*). Ex. 1003 at 1:23-2:2, 11:9-10. Dehydrofluorination of 236ea and 245eb may be carried out in separate reactors or simultaneously, in the same reactor. For example, separate feeds may

be fed to a single reactor in which steps (b) and (d) are carried out simultaneously. *Id.* at 3:4-14. Accordingly, *Smith* discloses steps (a)-(b) of claim 10 of the '282 patent.

117. *Masayuki* teaches the withdrawing step of claim 10 (step (c)). For all of the same reasons discussed above with regard to claim 1, applying the withdrawing step of *Masayuki* to the dehydrofluorination process of *Smith* results in withdrawing from the product stream a second product stream comprising spent DHA, as recited in step (c) of claim 10. *See supra*, ¶ 106.

118. The combination of *Masayuki* and *Harrison* teaches the recovering step of claim 10. The recovering step of claim 10 is identical to the recovering step of claim 1. Thus, the combination of *Masayuki* and *Harrison* teaches the recovering step of claim 10 for all of the same reasons discussed with regard to claim 1 above. *See supra*, ¶ 107.

119. Further, it would have been obvious to a POSITA to combine the withdrawing and recovering steps taught in *Masayuki* and *Harrison* with the hydrogenating and dehydrohalogenating steps of *Smith*, set forth in claim 10 for all of the same reasons as set forth above with regard to claim 1. Accordingly, in my opinion, the combination of *Smith*, *Masayuki,* and *Harrison* sets forth the elements of claim 10 in such a manner that a POSITA would have been able to practice the method of claim 10 with a reasonable expectation of success.

'282 patent claim	Disclosure from *Smith* (Ex. 1003)
10. A method for producing 2,3,3,3-tetrafluoropropene [1234yf] comprising: a. hydrogenating a starting material stream comprising hexafluoropropylene [1,1,2,3,3,3-hexafluoropropene (HFP)] by contacting said starting material stream with a reducing agent in a hydrogenation reactor to produce an intermediate stream comprising 1,1,1,2,3-pentafluoropropane [1,2,3,3,3-pentafluoropropane (245eb)] or 1,1,1,2,3,3-hexafluoropropane [1,1,2,3,3,3-hexafluoropropane (236ea)];	"The subject invention addresses the deficiencies of the known methods for preparing 1234yf by providing a process for the preparation of 1234yf comprising (a) contacting 1,1,2,3,3,3-hexafluoropropene (referred to hereinafter as 1216 or HFP) with hydrogen in the presence of a hydrogenation catalyst to produce 1,1,2,3,3,3-hexafluoropropane (referred to hereinafter as 236ea); … (c) contacting 1225ye with hydrogen in the presence of a hydrogenation catalyst to produce 1,2,3,3,3-pentafluoropropane (referred to hereinafter as 245eb)." (**Ex. 1003 at 1:23-2:2**.) "[T]he process may be carried out continuously with steps (a), (b), (c), and (d) being conducted sequentially in that order using a separate reactor for each step." (**Ex. 1003 at 2:16-17.**) "In a further reaction topology, steps (a) and (c) of the process of the invention may be carried out simultaneously in the same reactor. … The product of the reaction wherein steps (a) and (c) are conducted simultaneously in the same reactor comprises both 236ea and 245eb." (**Ex. 1003 at 2:29-3:5.**)
b. dehydrofluorinating, in the presence of a dehydrohalogenating agent, said 1,1,1,2,3-pentafluoropropane [1,2,3,3,3-pentafluoropropane (245eb)] or said 1,1,1,2,3,3-hexafluoropropane [236ea] in a dehydrofluorination reactor to produce a product stream comprising 2,3,3,3-tetrafluoropropene [1234yf] or	"The subject invention addresses the deficiencies of the known methods for preparing 1234yf by providing a process for the preparation of 1234yf comprising … (b) dehydrofluorinating 236ea to produce 1,2,3,3,3-pentafluoropropene (referred to hereinafter as 1225ye); … and (d) dehydrofluorinating 245eb to produce

1,2,3,3,3-pentafluoropropene [1225ye];	1234yf. (**Ex.1003 at 1:23-2:2**.) "The product of the reaction wherein steps (a) and (c) are conducted simultaneously in the same reactor comprise both 236ea and 245eb. These may be separated from each other (e.g. by distillation) before being fed into separate dehydrofluorination reactors for carrying out steps (b) and (d). Alternatively, … a combined stream of 236ea and 245eb may be fed to a single reactor. Thus, dehydrofluorination steps (b) and (d) may be carried out simultaneously in the same reactor. … Of course, separate feeds of 236ea and 245eb originating from separate hydrogenation reactors may be fed to a single dehydrofluorination reactor in which steps (b) and (d) are carried out simultaneously." (**Ex. 1003 at 3:4-14**.) "Another preferred method of effecting the dehydrofluorination in steps (b) and (d) is by contacting 236ea and/or 245eb with a base." (**Ex. 1003 at 11:9-10**.)
Claim 10 (cont.)	Disclosure from *Masayuki* (Ex. 1005)
c. withdrawing from the product stream a second product stream comprising spent dehydrohalogenating agent; and	(**Ex. 1005 Figure, stream 4**.) "The aqueous phase was extracted via Conduit 4 such that the level of Reactor 19 remained constant." (**Ex.1005 at 10:33-35**) "[A] mixture containing chloroprene, unreacted 3,4-dichloro-butene-1 and water produced by performing a reaction at a temperature of 20 – 100°C is removed in a gas phase via evaporation without reflux of said mixture into the reaction system." (**Ex. 1005 at 6:19-23**.)

Claim 10 (cont.)	Disclosure from *Masayuki* (Ex. 1005)	Disclosure from *Harrison* (Ex. 1006)
d. recovering spent dehydrohalogenating agent.	(**Ex. 1005 Figure, decanter 20, enricher 21, centrifuge 25**.) "The aqueous phase was extracted via Conduit 4 such that the level of Reactor 19 remained constant and the lightly mixed lipid and aqueous phases (including precipitated sodium chloride) were separated using Decanter 20, after which the lipid phase was returned to the reactor via Conduit 5." (**Ex. 1005 at 10:33-11:1**.) "The aqueous phase … was fed into a forced circulation-type Enricher 21 via Conduit 6 and concentration was carried out … After passing through Conduit 9 from Conduit 8, the aqueous phase was heated in Heat Exchanger 22 after which it was circulated in Enricher 21 via Conduit 10." (**Ex. 1005 at 11:1-9**.) "As concentration was performed, dissolved sodium chloride precipitated out, but said aqueous phase was	" . . . (b) contacting [an aqueous solution of potassium fluoride and potassium hydroxide] with finely divided high purity lime to thereby obtain a calcium fluoride precipitate in aqueous potassium hydroxide (c) settling the reaction product of step (b) into two phases comprising an aqueous potassium hydroxide supernatant and an aqueous slurry of calcium fluoride; (d) recovering the aqueous potassium hydroxide supernatant . . ." (**Ex.1006 2:14-21**.) "The basic potassium fluoride solution is then mixed with solid hydrated (slaked) lime in a stirred vessel where this calcium hydroxide [$Ca(OH)_2$] reacts to form the calcium fluoride precipitate and regenerate the potassium hydroxide." (**Ex. 1006 at 3:6-10**.)

	extracted via Conduit 8, directed into Slurry Tank 24 via Conduit 11 and fed into Centrifuge where precipitated sodium chloride was separated out and also discarded via Conduit 12." (**Ex.1005 at 11:9-14**.)	

W. Claims 11 and 12 of the '282 Patent are Obvious over Smith in View of Masayuki and Harrison

120. Claim 11 depends from claim 10 and recites "… wherein the second product stream further comprises one or more dissolved organics." Claim 12 depends from claim 11 and recites "…wherein the dissolved organics are selected from the group consisting of 1,1,1,2,3,3-hexafluoropropane (HFC-236ea), 1,1,1,2,3-pentafluoropropane (HFC-245eb), and combinations thereof." As explained above for claims 28 and 29, *Smith* describes the use of organic co-solvents or diluents in combination with water and base (e.g., KOH) in the aqueous phase in dehydrofluorination reactions. Exemplary diluents include fluorinated diluents such as hexafluoroisopropanol, perfluorotetrahydrofuran, and perfluorodecalin in the dehydrofluorination reaction mixture. Ex. 1003 at 12:27-13:4. Other prior art references also describe the use of non-aqueous solvents in base-mediated dehydrofluorination reactions wherein 236ea and 245eb are converted to 1225ye and 1234yf, respectively. For example, *Knunyants*, which published in 1960 and is

therefore prior art to the '282 patent, discloses the use of an organic solvent in an exemplary base-mediated dehydrofluorination process wherein 236ea is converted to 1225ye using KOH. Ex. 1008 at 1316 ("Dehydrofluorination of 1,1,1,2,3,3-Hexafluoropropane"). Further, *Mahler*, which published November 12, 2009, and is therefore prior art to the '282 patent, discloses the dehydrofluorination of 245eb using an aqueous alkaline [KOH] solution, wherein a non-aqueous co-solvent in which 245eb is at least partially miscible is present. Ex. 1009 at ¶¶ [0052] and [0086]. Thus, one of ordinary skill in the art would be familiar with base-mediated dehydrofluorination processes conducted with non-aqueous solvents or co-solvents in which organics, such as 245eb, are at least partially miscible. Given the solubility of the fluoroalkane starting materials (e.g., 236ea and 245eb) in organic liquids, a POSITA would expect some portion of the organic starting materials to be dissolved in the organic co-solvent or diluent component of the reaction stream. Accordingly, in my opinion, the combination of *Smith*, *Masayuki,* and *Harrison* sets forth the elements of claims 11 and 12 in such a manner that a POSITA would have been able to practice the method claimed method with a reasonable expectation of success.

'282 patent claim	Disclosure from *Smith* (Ex. 1003)
11. The method of claim 10 wherein the second product stream further comprises one or more dissolved organics.	"Thus, the dehydrofluorination reaction may preferably use an aqueous solution of at least one base … without the need for a co-solvent or diluent. However, a co-solvent or diluent can be used … to act as a preferred phase for reaction by-products…. Useful

	co-solvents or diluents include those that are not reactive with or negatively impact the equilibrium or kinetics of the process and include alcohols such as methanol and ethanol; diols such as ethylene glycol; ethers such as diethyl ether, dibutyl ether; esters such as methyl acetate, ethyl acetate and the like; linear, branched and cyclic alkanes such as cyclohexane, methylcyclohexane; fluorinated diluents such as hexafluoroisopropanol, perfluorotetrahydrofuran and perfluorodecalin." (**Ex.1003 at 12:27-13:4**.)
12. The method of claim 11 wherein the dissolved organics are selected from the group consisting of 1,1,1,2,3,3-hexafluoropropane (HFC-236ea), 1,1,1,2,3-pentafluoropropane (HFC-245eb), and combinations thereof.	"Thus, the dehydrofluorination reaction may preferably use an aqueous solution of at least one base … without the need for a co-solvent or diluent. However, a co-solvent or diluent can be used … to act as a preferred phase for reaction by-products…. Useful co-solvents or diluents include those that are not reactive with or negatively impact the equilibrium or kinetics of the process and include alcohols such as methanol and ethanol; diols such as ethylene glycol; ethers such as diethyl ether, dibutyl ether; esters such as methyl acetate, ethyl acetate and the like; linear, branched and cyclic alkanes such as cyclohexane, methylcyclohexane; fluorinated diluents such as hexafluoroisopropanol, perfluorotetrahydrofuran and perfluorodecalin." (**Ex.1003 at 12:27-13:4**.)

X. Claims 13 and 14 of the '282 Patent are Obvious over Smith in View of Masayuki and Harrison

121. Claim 13 recites "…wherein the spent KOH is purified using at least one separation method." Claim 14 recites "…wherein the separation method is selected from the group consisting of distillation or phase separation." For the reasons set forth above with respect to claims 30 and 41 (corresponding to claim 13) and claims 31 and 42 (corresponding to claim 14), respectively, it is my

opinion that the combination of *Smith*, *Masayuki*, and *Harrison* sets forth the elements of claims 13 and 14 in such a manner that a POSITA would have been able to practice the method of claims 13 and 14 with a reasonable expectation of success. *See supra*, ¶ 91-94.

'282 patent claim	Disclosure from *Masayuki* (Ex. 1005)	Disclosure from *Harrison* (Ex. 1006)
13. The method of claim 10 wherein the spent dehydrohalogenating agent is purified using at least one separation method.	(**Ex. 1005 Figure, decanter 20 and centrifuge 25**.) "The aqueous phase was extracted via Conduit 4 such that the level of Reactor 19 remained constant and the slightly mixed lipid and aqueous phases (including precipitated sodium chloride) were separated using Decanter 20." (**Ex. 1005 at 10:33-37**.)	". . . (b) contacting [an aqueous solution of potassium fluoride and potassium hydroxide] with finely divided high purity lime to thereby obtain a calcium fluoride precipitate in aqueous potassium hydroxide; (c) settling the reaction product of step (b) into two phases comprising an aqueous potassium hydroxide supernatant and an aqueous slurry of calcium fluoride; (d) recovering the aqueous potassium hydroxide supernatant . . ." (**Ex.1006 2:14-21**.)
14. The method of claim 13 wherein the separation method is selected from the group consisting of distillation or phase separation.	(**Ex. 1005 Figure, decanter 20 and centrifuge 25**.) "The aqueous phase was extracted via Conduit 4 such that the level of Reactor 19 remained constant and the slightly mixed lipid and aqueous phases (including precipitated sodium chloride) were separated using	". . . (b) contacting [an aqueous solution of potassium fluoride and potassium hydroxide] with finely divided high purity lime to thereby obtain a calcium fluoride precipitate in aqueous potassium hydroxide; (c) settling the reaction product of step (b) into two phases comprising an aqueous potassium hydroxide supernatant and an aqueous slurry of calcium fluoride; (d) recovering the aqueous potassium hydroxide supernatant

	Decanter 20." (**Ex. 1005 at 10:33-37**.)	. . ." (**Ex.1006 2:14-21**.)

Y. Claim 15 of the '282 Patent is Obvious over Smith in View of Masayuki and Harrison

122. Claim 15 further provides "optionally, concentrating the purified [DHA] and recycling it back to the dehydrohalogenation reaction." Although concentrating the purified DHA in claim 15 is recited as "optional" and is therefore not necessary to establish invalidity, the combination of *Smith*, *Masayuki* and *Harrison* describes all aspects of claim 15. For the reasons explained above with regard to claims 32 and 43, it is my opinion that the combination of *Smith*, *Masayuki* and *Harrison* sets forth the elements of claim 15 in such a manner that a POSITA would have been able to practice the method of claim 15 with a reasonable expectation of success. *See supra*, ¶¶ 95-96.

'282 patent claim	Disclosure from *Masayuki* (Ex. 1005)
15. The method of claim 10 further comprising, optionally, concentrating the purified dehydrohalogenating agent and recycling it back to the dehydrohalogenation reaction.	"The aqueous phase containing solid sodium chloride from which the lipid phase was removed using Decanter 20 was fed into forced circulation-type Enricher 21 via Conduit 6 and concentration was carried out … As concentration was performed, dissolved sodium chloride precipitated out, but said aqueous phase was extracted via Conduit 8, directed into Slurry Tank 24 via Conduit 11 and fed into Centrifuge 25 where precipitated sodium chloride was separated out … Recovered sodium hydroxide aqueous solution was returned to Conduit 2 via Conduit 13 and fed back into the reaction." (**Ex. 1005 at 11:1-16**.)

Z. Claim 16 of the '282 Patent is Obvious over Smith in View of Masayuki and Harrison

123. Claim 16 requires that the reaction stream further comprises by-product salts of the DHA (e.g., KF). As discussed above for claims 33 and 44, *Smith* describes a dehydrofluorination reaction in which a fluoroalkane (e.g., 245eb) is reacted with a DHA (e.g., KOH) to produce a fluoroalkene. Ex. 1003 at 1:23-2:2, 11:9-15. Further, a POSITA would understand that KF is a by-product salt of the dehydrofluorination of 245eb with KOH. Ex.1010 at 13:16-22. Thus, for the reasons discussed above with regard to claims 33 and 44, it is my opinion that the combination of *Smith*, *Masayuki*, and *Harrison* sets forth the elements of claim 16 in such a manner that a POSITA would have been able to practice the method of claim 16 with a reasonable expectation of success. *See supra*, ¶ 97.

'282 patent claim	Disclosure from *Smith* (Ex. 1003)
16. The method of claim 10 wherein the reaction stream further comprises by-product salts of the dehydrohalogenating agent.	"The subject invention addresses the deficiencies of the known methods for preparing 1234yf by providing a process for the preparation of 1234yf comprising …(b) dehydrofluorinating 236ea to produce 1,2,3,3,3-pentafluoropropene (referred to hereinafter as 1225ye); … and (d) dehydrofluorinating 245eb to produce 1234yf ." (**Ex. 1003 at 1:23-2:2**.) "Another preferred method of effecting the dehydrofluorination in steps (b) and (d) is by contacting 236ea and/or 245eb with a base. Preferably, the base is a metal hydroxide …, e.g. an alkali or alkaline earth metal hydroxide or amide). … the term "alkali metal hydroxide" [refers] to a compound or mixture of compounds selected from lithium hydroxide, sodium hydroxide, potassium hydroxide, rubidium hydroxide and caesium hydroxide."

	(**Ex. 1003 at 11: 9-15**.)

AA. Claim 17 of the '282 Patent is Obvious over Smith in View of Masayuki and Harrison

124. Claim 17 recites converting by-product salts (e.g. KF) to the DHA (e.g., KOH). As discussed above with regard to claim 34, *Harrison* describes converting a by-product salt (i.e., KF) to the DHA (i.e., KOH) using $Ca(OH)_2$. Ex. 1006 at 2:14-16, 3:6-10; *supra* at ¶ 98. Accordingly, in my opinion, the combination of *Smith*, *Masayuki*, and *Harrison* sets forth the elements of claim 17 in such a manner that a POSITA would have been able to practice the method of claim 17 with a reasonable expectation of success.

'282 patent claim	Disclosure from *Harrison* (Ex. 1006)
17. The method of claim 16 further comprising converting the by-product salts to the DHA.	"(b) contacting [an aqueous solution of potassium fluoride and potassium hydroxide] with finely divided high purity lime to thereby obtain a calcium fluoride precipitate in aqueous potassium hydroxide." (**Ex. 1006 at 2:14-16**.) "The basic potassium fluoride solution is then mixed with solid hydrated (slaked) lime in a stirred vessel where this calcium hydroxide [$Ca(OH)_2$] reacts to form the calcium fluoride precipitate and regenerate the potassium hydroxide." (**Ex. 1006 at 3:6-10**.)

BB. Claim 18 of the '282 Patent is Obvious over Smith in View of Masayuki and Harrison

125. Claim 18 states that "…the dehydrohalogenating agent is KOH and the by-

product salt is KF." As discussed above for claim 16, *Smith* describes a dehydrofluorination reaction in which a fluoroalkane (e.g., 245eb) is reacted with a DHA (e.g., KOH) to produce a fluoroalkene. Ex. 1003 at 1:23-2:2, 11:9-15. A POSITA would understand that KF is a by-product salt of the dehydrofluorination of 245eb with KOH. Ex.1010 at 13:16-22. Accordingly, in my opinion, the combination of *Smith*, *Masayuki*, and *Harrison* sets forth the elements of claim 18 in such a manner that a POSITA would have been able to practice the method of claim 18 with a reasonable expectation of success. *See supra*, ¶ 124.

'282 patent claim	Disclosure from *Smith* (Ex. 1003)
18. The method of claim 16 wherein the dehydrohalogenating agent is KOH and the by-product salt is KF.	"The subject invention addresses the deficiencies of the known methods for preparing 1234yf by providing a process for the preparation of 1234yf comprising …(b) dehydrofluorinating 236ea to produce 1,2,3,3,3-pentafluoropropene (referred to hereinafter as 1225ye); … and (d) dehydrofluorinating 245eb to produce 1234yf ." (**Ex. 1003 1:23-2:2**.) "Another preferred method of effecting the dehydrofluorination in steps (b) and (d) is by contacting 236ea and/or 245eb with a base. Preferably, the base is a metal hydroxide …, e.g. an alkali or alkaline earth metal hydroxide or amide). … the term "alkali metal hydroxide" [refers] to a compound or mixture of compounds selected from lithium hydroxide, sodium hydroxide, potassium hydroxide, rubidium hydroxide and caesium hydroxide." (**Ex. 1003 at 11: 9-15**.)

CC. Claim 19 of the '282 Patent is Obvious over Smith in View of Masayuki and Harrison

126. Claim 19 depends from claim 18 and provides "optionally, concentrating the converted KOH and recycling it back to the dehydrohalogenation reaction." For the reasons discussed above with regard to claims 35 and 46, it is my opinion that the combination of *Smith*, *Masayuki*, and *Harrison* sets forth the elements of claim 19 in such a manner that a POSITA would have been able to practice the method of claim 19 with a reasonable expectation of success. *See supra*, ¶ 99-100.

'282 patent claim	Disclosure from *Masayuki* (Ex. 1005)	Disclosure from *Harrison* (Ex. 1006)
19. The method of claim 18 further comprising, optionally, concentrating the converted KOH and recycling it back to the dehydrohalogenation reaction.	"The aqueous phase containing solid sodium chloride from which the lipid phase was removed using Decanter 20 was fed into forced circulation-type Enricher 21 via Conduit 6 and concentration was carried out … As concentration was performed, dissolved sodium chloride precipitated out, but said aqueous phase was extracted via Conduit 8, directed into Slurry Tank 24 via Conduit 11 and fed into Centrifuge 25 where precipitated sodium chloride was separated out …. Recovered sodium hydroxide aqueous solution was returned to Conduit 2 via Conduit 13 and fed back into the reaction." (**Ex. 1005 at 11:1-16**.)	"(b) contacting [an aqueous solution of potassium fluoride and potassium hydroxide] with finely divided high purity lime to thereby obtain a calcium fluoride precipitate in aqueous potassium hydroxide." (**Ex. 1006 at 2:14-16**.) "The basic potassium fluoride solution is then mixed with solid hydrated (slaked) lime in a stirred vessel where this calcium hydroxide [$Ca(OH)_2$] reacts to form the calcium fluoride precipitate and regenerate the potassium hydroxide." (**Ex. 1006 at 3:6-10**.)

DD. Claim 20 of the '282 Patent is Obvious over Smith in View of Masayuki and Harrison

127. Claim 20 is directed to converting KF to KOH in the presence of $Ca(OH)_2$. For the reasons discussed above with regard to claim 34, it is my opinion that the combination of *Smith*, *Masayuki*, and *Harrison* sets forth the elements of claim 20 in such a manner that a POSITA would have been able to practice the method of claim 20 with a reasonable expectation of success. *See supra*, ¶ 98.

'282 patent claim	Disclosure from *Harrison* (Ex. 1006)
20. The method of claim 18 further comprising converting KF to KOH in the presence of $Ca(OH)_2$.	"(b) contacting [an aqueous solution of potassium fluoride and potassium hydroxide] with finely divided high purity lime to thereby obtain a calcium fluoride precipitate in aqueous potassium hydroxide." (**Ex. 1006 at 2:14-16**.) "The basic potassium fluoride solution is then mixed with solid hydrated (slaked) lime in a stirred vessel where this calcium hydroxide [$Ca(OH)_2$] reacts to form the calcium fluoride precipitate and regenerate the potassium hydroxide." (**Ex. 1006 at 3:6-10**.)

XI. Conclusion

128. In conclusion, as explained above, in my opinion, claims 1-46 are obvious over *Smith* in view of *Masayuki* and *Harrison*.

129. In signing this Declaration, I recognize that the Declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place within

the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

130. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Respectfully submitted,

Leo E. Manzer, Ph.D.

Date: __April 1, 2015_____

EXHIBIT A

Leo E. Manzer

328 Cassell Ct.
Wilmington, DE 19803
Office: (302) 478-3514
Cell: (302) 540-4362
Leo@CatalyticInsights.com

Born - Timmins, Ontario, Canada

Citizenship - Dual: United States and Canada

Education

1970 B.Sc. (Honors Chemistry)
University of Waterloo
Waterloo, Ontario, Canada

1973 Ph.D. (Chemistry)
University of Western Ontario
London, Ontario, Canada

Career Highlights:

Manzer spent 32 years of his professional career at DuPont in Delaware and Texas. During his entire career he was active in catalysis and process development. He was personally active in the laboratory and rose to the position of Director of DuPont's Corporate Catalyst Center (which he founded). He was always active in the laboratory and played a leading role in many activities which are highlighted below.

2005-Present: President and Founder of Catalytic Insights, LLC
Following retirement from DuPont in 2005, Manzer founded Catalytic Insights, LLC (www.CatalyticInsights.com). His company is very active consulting for many large and small companies in Europe and the USA, in the area of catalysis and process development, particularly in the active field of biomass to fuels and chemicals. He works with several venture capital firms, to evaluate startup companies for potential funding. He serves on the Scientific Advisory Board of several companies. In 2008 he was an expert witness in a patent law suit at the International Trade Commission in 2008. His team won the case. He continues to be invited to give many plenary lectures at key conferences and symposia.

1997-2005: DuPont Fellow
In 1997 Manzer was appointed DuPont Fellow, one of only 14 in the company out of 5000 scientists and engineers. In 2000 he was appointed chairman of the DuPont Fellow's Forum and continued to play a leadership role in that organization until retirement. In this highly influential and prestigious position, he had interactions with senior DuPont management and was involved in some key corporate activities.

2000-2005: Biomass Conversion to Renewable Fuels and Chemicals
In 2000 DuPont's CEO, stated that by 2010 DuPont would derive 25% of its revenue from businesses not requiring delectable resources. As a result, a major corporate effort was started to grow businesses based on biomass feedstocks. Manzer led the effort to identify platform molecules and to evaluate new market opportunities based on these renewable derivatives. A large number of patents and product opportunities resulted from this effort.

They include acrylic monomers for high Tg polymers, new routes to nylon intermediates, lactones and pyrrolidones as solvents and surfactants, ionic liquids and biofuels.

1998-2000: Gas-to-Liquids
During this period DuPont owned Conoco Inc. Although Conoco had large gas reserves they had little expertise in catalysis. Manzer was asked by Conoco to initiate a program for the conversion of natural gas to linear alkanes for diesel fuel (GTL). As a result of this effort, Conoco developed tremendous experience and IP in this well researched field. During this activity Conoco was sold by DuPont, but the groundwork and R&D effort gave Conoco a world class process in the GTL area. They subsequently built a 400 barrel/day pilot plant that operated successfully and were one of 4 oil companies selected by Qatar to build $ 4+ billion demonstration units. Although that project did not proceed Conoco-Phillips continues to explore other areas for commercialization.

1990-1995: Fluoromonomers
Nafion® is an important business for DuPont and a key component of fuel cells. Tetrafluoroethylene (TFE) and hexafluoropropylene (HFP) are the key main ingredients in Nafion®. Production of both of these monomers generates significant amounts of highly toxic byproducts and the process is expensive to operate. Manzer initiated a large program to develop lower cost processes for the production of these two monomers. A number of patents were issued based on a wide variety of new technologies such as electrochemical fluorinations, chlorofluorination of hydrocarbons, and inductively heated pyrolysis reactors.

1986-2000: Chlorofluorocarbon (CFC) Alternatives
DuPont was the world's largest producer of chlorofluorocarbons (CFCs) for decades so when science linked CFCs to the depletion of the Antarctic ozone layer in 1986, DuPont management committed to phasing out CFCs in an orderly fashion and developing alternatives such as hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs) as quickly as possible. Manzer lead the R&D effort to develop manufacturing routes to these new products. During this period over 300 patents were issued to DuPont and $ 500 million in capital and R&D was spent. Over 7 commercial plants were built to enable DuPont to keep a global leadership position with over $ 600 million in annual sales. Manzer was also the only corporate spokesman on technology issues related to CFCs. The processes were widely diverse using gas and liquid phase reactors with very hazardous ingredients such as HF and chlorine. DuPont was recognized in 2002 for this effort by the Presidential Medal of Technology Award. Manzer was one of three scientists in DuPont recognized for this large effort.

1997-1999: Environmentally Safer Phosgene Catalysts
Early in 1997 DuPont's plant at Chamber's Works NJ, was nearly shut down due to high levels of carbon tetrachloride emissions. The CCl_4 was traced to the phosgene plant which provided the feedstock for the important, profitable products Tyvek® and Kevlar®. Manzer convinced the business to delay the installation of end-of-pipe abatement facilities (many millions of dollars) and solved the problem at the source by developing better catalysts. An R&D effort indicated that the CCl_4 emissions were resulting from reaction of chlorine with the carbon catalyst that had been used in the process for over 30 years. A new catalyst was quickly discovered and implemented directly into the plant resulting in a reduction of 95^{+}% of the CCl_4 emissions, allowing the plant to continue operation. The commercialization was a 250,000x scale-up from the lab to the plant. The new catalyst resulted in significant economic savings to DuPont due to a 20% capacity increase. The new catalyst has a lifetime of >5 years, compared with 6 months for the initial catalyst. The technology was licensed to other large phosgene producers.

1987-1995: Corporate Catalysis Center
During the 1980's catalysis in US industry was perceived as being mature and efforts in academia and industry were shifted to other areas. Manzer became concerned that resources at DuPont were below critical mass and indeed catalysis played a key role in DuPont's

businesses. After showing that DuPont operated over 169 commercial catalytic processes resulting in 10's of billions of dollars in revenue, he reversed the downsizing trend at DuPont and founded the Corporate Catalysis Center (CCC). He was Director of this Center and under his leadership the CCC soon became globally recognized as one of the leading industrial centers of catalysis in the world. The Center had over 150 scientists and engineers from all of DuPont's businesses at its peak. Manzer was recognized with the 1995 Earle Barnes ACS Award for leadership in R&D management for establishing the Center.

1973-2004: Homogeneous Catalysis
Manzer began his career in DuPont as an organometallic chemist doing synthesis and homogeneous catalysis. During his career he maintained interest in this field and was recognized by a number of awards.

Awards:

1966 Cyanamid of Canada Science Award
1970 Society of Chemical Industry Merit Award
1970 National Research Council of Canada Postgraduate Scholarship
1987 Sandford-Fleming Award in Chemical Engineering from the University of Waterloo
1995 American Chemical Society-Earle B. Barnes Award for Leadership in Chemical Research Management sponsored by the Dow Chemical Company
1996 Devon Meek Industrial Lectureship, Ohio State University
1996 DuPont Engineering Excellence Award
1996 DuPont Safety, Health and Environmental Excellence Award
1996 Barnette Industrial Lectureship, University of West Virginia
1997 American Chemical Society Hero Of Chemistry Award
1997 Catalysis Club of Philadelphia Award
1997 US Government Hammer Award
1998 Cross-Canada Lecture Tour Award by the Catalysis Division of the Chemical Institute of Canada
2001 Eugene J. Houdry Award in Applied Catalysis by the North American Catalysis Society
2003 E. V. Murphree Award by the American Chemical Society for Industrial Science and Engineering
2003 One of three team members recognized for the 2002 National Medal of Technology Award to the DuPont Company, "for policy and technology leadership in the phaseout and replacement of chlorofluorocarbons"
2004 The Tarrant Distinguished Visiting Professorship, University of Florida, February 23-27, 2004
2007 University of Waterloo Distinguished Alumni Award
2011 Presidential Green Chemistry Challenge Award to BioAmber, Inc.
2014 DuPont Stephanie Kwolik Award to inventors with over 100 US patents

Professional Activities

American Chemical Society
American Institute of Chemical Engineering
North American Catalysis Society
Industrial Advisory Board, Center for Catalytic Science & Technology, University of Delaware
NRC Panel on "New Directions in Catalyst Science & Technology" (1989-1991)
Executive Committee for the 11th International Congress on Catalysis-Baltimore 1996
Treasurer-11th International Congress on Catalysis-Baltimore 1996
Editorial Board of Catalysis Reviews
Editorial Board of Catalysis Today

Editorial Board of Applied Catalysis A: General
Editorial Board of Industrial Catalysis News
Editorial Board of Clean Products and Processes
Editorial Board of Chemistry for Sustainable Development
Editorial Board, C&E News
Editorial Board, Journal of Catalysis, 2000-2006
Adjunct Professor, Dept of Chemistry and Biochemistry, University of Delaware,1990-2005
Adjunct Professor, Dept of Chemical Engineering, University of Delaware, 1990-2005
Advisory Board-Environmentally Conscious Chemical Manufacturing Center, University of Virginia, Charlottesville, VA.
Advisory Board-Department of Chemistry, Vanderbilt University, Nashville, Tennessee
Advisory Board-Department of Chemical Engineering, Tulane University, New Orleans, LA.
Led industry-wide effort to establish Catalysis as a focus area in the Advanced Technology Program (ATP) at NIST. This effort was successful in obtaining $ 160 million in funding for the 1995-2000 period.
Chairman, Catalysis Advisory Board, Los Alamos National Laboratory
Organizer and Treasurer-3rd World Congress on Oxidation Catalysis-San Diego, September 1997
Delaware Section ACS Carothers Award Committee (1996-2007)
Organizer and Treasurer-2nd World Congress on Environmental Catalysis, Miami Beach, November 1998
Advisory Board- Steacie Institute for Molecular Sciences, National Research Council of Canada (1999-present)
Advisory Board 3rd International Conference on Environmental Catalysis, Tokyo, Japan, December 10-13 (2001)
International Advisory Board, Tokyo Conference on Advanced Catalytic Science and Technology (TOCAT4), 2002
NATO Advanced Workshop on "Green Industrial Applications of Ionic Liquid", Crete, Greece April 12-16 (2000)
Advisory Board – Center for Catalysis Research and Innovation, University of Ottawa, Ottawa Ontario Canada (2002-Present)

Professional Progression

1973 Research Chemist, DuPont Central R&D, Experimental Station, Wilmington, DE.
1976 Research Chemist, DuPont Polymer Products, Experimental Station, Wilmington, DE.
1977 Group Leader-Homogeneous & Heterogeneous Catalysis, DuPont Central R&D, Experimental Station, Wilmington, DE.
1979 Research Supervisor-DuPont Petrochemicals Department, Experimental Station, Wilmington, DE.
1980 Technical Superintendent-DuPont Petrochemicals Department, Victoria, TX.
1984 Research Supervisor-DuPont Central R&D, Experimental Station, Wilmington, DE.
1987 Research Manager, DuPont Central R&D Experimental Station, Wilmington, DE.
1989 Manager, Corporate Catalysis Center Central Science and Engineering, Experimental Station, Wilmington, DE.
1992 Associate Director-Chemical Science, Central Science & Engineering, Experimental Station, Wilmington, DE.
1992 Director, Corporate Catalysis Center, Central Science and Engineering, Experimental Station, Wilmington, DE.
1997 DuPont Fellow, Central Science and Engineering, Experimental Station, Wilmington, DE.
2000 Chairman of the DuPont Fellow's Forum
2005 Retired from DuPont
2005 Founded Catalytic Insights LLC

Issued U. S. Patents by Technology Area (158) issued + 60 filed or in preparation)

Catalytic Conversion of Biomass

US 8,937,147 (2015)	Processes for producing diaminobutane, succinic dinitrile and succinamide
US 8,895,779 (2014)	Processes for producing monoammonium adipate and conversion
US 8,748,638 (2014)	Processes for Preparing Diacids, Dialdehydes and Polymers
US 8,748,637 (2014)	Processes for Preparing Diacids, Dialdehydes and Polymers
US 8,703,900 (2014)	Processes for producing caprolactam and derivatives
US 8,633,325 (2014)	Method for making insect repellent composition
US 8,574,405 (2013	System for Conveying Biomass
US 8,575,299 (2013)	Processes for Preparing Diacids, Dialdehydes and Polymers
US 8,558,015 (2013)	Solvent addition and removal in the hydrogenation of catmint
US 8,552,210 (2013)	Hydrogenation of catmint oil
US 8,546,627 (2013)	Renewable Compositions
US 8,524,923 (2013)	Processes for Preparing Diacids, Dialdehydes and Polymers
US 8,507,718 (2013)	Ketocarboxylic acids, methods of manufacture and uses thereof
US 8,487,149 (2013)	Renewable Compositions
US 8,466,300 (2013)	Processes for the production of hydrogenated products
US 8,450,543B2 (2013)	Integrated Methods of Preparing Renewable Chemicals
US 8,410,291 (2013)	Processes for the production of hydrogenated products
US 8,399,687 (2013)	Processes for the production of hydrogenated products
US 8,378,160 (2013)	Renewable compositions
US 8,329,229 (2012)	Steam distillation of catmint plants
US 8,314,260 (2012	Hydroxymethylfurfural ethers and esters prepared in ionic liquids
US 8,293,317 (2012)	Hydrogenation of caryophellene
US 8,193,402 (2012)	Renewable compositions
US 8,193,375B2 (2012)	Processes for the production of hydrogenated products
US 8,129,550 (2012)	Oxidation of 5-(hydroxymethyl) furfural to 2,5-diformylfuran and subsequent decarbonylation to unsubstituted furan
US 8,084,626 (2011)	Processes for the production of hydrogenated products
US 7,956,203 (2011)	Oxidation of 5-(hydroxymethyl) furfural to 2,5-diformylfuran and subsequent decarbonylation to unsubstituted furan
US 7,754,928 (2010)	Method of making 2-butanol
US 7,745,672 (2010	Catalytic conversion of ethanol and methanol to an isobutanol-containing reaction product using a thermally decomposed hydrotalcite/metal
US 7,705,192 (2010)	Catalytic conversion of ethanol and methanol to an isobutanol-containing reaction product using a thermally decomposed hydrotalcite catalyst
US 7,700,813 (2010)	Catalytic conversion of ethanol and methanol to an isobutanol-containing reaction product using a thermally decomposed hydrotalcite containing the anion of ethylenediaminetetraacetic acid
US 7,700,812 (2010)	Catalytic conversion of ethanol to a 1-butanol-containing reaction product using a thermally decomposed hydrotalcite containing the anion of ethylenediaminetetraacetic acid
US 7,700,811 (2010)	Catalytic conversion of ethanol to a 1-butanol-containing reaction product using a thermally decomposed hydrotalcite/metal carbonate
US 7,700,810 (2010)	Catalytic conversion of ethanol to a 1-butanol-containing reaction product using a thermally decomposed hydrotalcite catalyst
US 7,671,247 (2010)	Method for purifying alkane liquids

US 7,625,941 (2009)	Ionic Liquids
US 7,612,216 (2009)	Production of N-(methyl aryl)-2-lactam, N-(methyl cycloalkyl)-2-lactam and N-alkyl-2-lactam by reductive amination of lactones with aryl and alkyl cyano compounds
US 7,547,793 (2009)	Method for making insect repellent composition
US 7,465,813 (2008)	Process for making 5-methyl-N-alkyl-2-pyrrolidone from alkyl amine(s) and levulinic acid
US 7,405,330 (2008)	Preparation of polytrimethylene ether glycol and copolymers thereof
US 7,402,711 (2008)	Preparation of poly(tetramethylene) glycol
US 7,348,442 (2008)	Gas phase synthesis of methylene lactones using catalysts derived from hydrotalcite precursors
US 7,314,962 (2008)	Alkylation of Aromatic Compounds
US 7,314,942 (2008)	Methylenelactone synthesis in supercritical fluids
US 7,205,416 (2007)	Liquid phase synthesis of methylene lactones using novel grafted catalyst
US 7,199,254 (2007)	Liquid phase synthesis of methylene lactones using novel catalyst
US 7,166,727 (2007)	Supercritical fluid phase synthesis of methylene lactones using novel grafted catalyst
US 7,164,033 (2007)	Gas phase synthesis of methylene lactones using novel catalyst
US 7,164,032 (2007)	Supercritical fluid phase synthesis of methylene lactones using novel catalyst field of invention
US 7,161,014 (2007)	Gas phase synthesis of methylene lactones using novel grafted catalyst
US 7,157,588 (2007)	Ionic Liquids
US 7,153,996 (2006)	Preparation of levulinic acid esters and formic acid esters from biomass and olefins
US 7,153,981 (2006)	Supercritical fluid phase synthesis of methylene lactones using oxynitride catalyst
US 7,151,185 (2006)	Gas phase synthesis of methylene lactones using oxynitride catalyst
US 7,141,682 (2006)	Liquid phase synthesis of methylene lactones using oxynitride catalyst
US 7,129,362 (2006)	Production of 5-methyl-N-aryl-2-pyrrolidone and 5-methyl-N-alkyl-2-pyrrolidone by reductive of levulinic acid esters with aryl and alkyl amines
US 7,074,968 (2006)	Continuous process for the preparation of polytrimethylene ether glycol
US 7,067,677 (2006)	Production of dihydronepetalactone by hydrogenation of nepetalactone
US 7,030,249 (2006)	Process for converting alpha-angelica lactone to 5-methyl-N-alkyl- 2-pyrrolidone using alkyl amines
US 7,030,074 (2006)	Production of 5-methyl-N-(methyl aryl)-2-pyrrolidone, 5-methyl-N-(methyl cycloalkyl)-2-pyrrolidone and 5-methyl-N-alkyl-2-pyrrolidone by reductive amination of levulinic acid esters with cyano compounds
US 7,025,819(B2) (2006)	Production of 5-methyl-n-(methyl aryl)-2-pyrrolidone, 5-methyl-n-(methyl cycloalkyl)-2-pyrrolidonea and 5-methyl-n-alkyl-2-pyrrolidone by reductive amination of levulinic acid esters with cyano compounds
US 7,019,155(B2) (2006)	Hydrogenation of tetrahydroxybutane to tetrahydrofuran
US 7,014,697(B2) (2006)	Production of 5-methyl-n-(methyl aryl)-2-pyrrolidone, 5-methyl-n-(methyl cycloalkyl) -2-pyrrolidone and 5-methyl-n-alkyl-2-pyrrolidone by reductive amination of levulinic acid esters with cyano compounds
US 7,002,024 (B2) (2006)	Production of N-aryl-2-lactam and N-alkyl-2-lactam by reductive amination of lactones with aryl amines

US 6,995,275 (2006)	Production of N-aryl-2-lactam and N-alkyl-2-lactam by reductive amination of lactones with aryl and alkyl nitro compounds
US 6,992,195 (2006)	Production of N-aryl-2-lactam and N-cycloalkyl-2-lactam by reductive amination of lactones with arylamines
US 6,991,744 (2006)	Refrigerant Compositions Containing a Compatibilizer
US 6,987,192 (2006)	Production of N-aryl-2-lactam and N-alkyl-2-lactam by reductive amination of lactones with aryl and alkyl nitro compounds
US 6,984,736 (2006)	Production of N-aryl-2-lactam and N-alkyl-2-lactam by reductive amination of lactones with aryl and alkyl nitro compounds
US 6,982,339 (2006)	Production of N-aryl-2-lactam and N-cycloalkyl-2-lactam by reductive amination of lactones with aryl amines
US 6,977,291 (2005)	Production of Polytrimethylene Ether Glycol and Copolymers Thereof
US 6,946,563 (2005)	Production of 5-methyl-dihydro-furan-2-one from levulinic acid in supercritical media
US 6,930,126 (2005)	Production of 5-Methyl-N-(Methylaryl)-2-Pyrrolidone, 5-Methyl-N-(Methylcycloalkyl)-2-Pyrrolidone and 5-Methyl-N-Alkyl-2-Pyrrolidone by Reductive Amination of Levulinic Acid Esters with Cyano Compounds
US 6,916,842 (2005)	Production of 5-Methyl-N-(Methylaryl)-2-Pyrrolidone, 5-Methyl-N-(Methylcycloalkyl)-2-Pyrrolidone and 5-Methyl-N-Alkyl-2-Pyrrolidone by Reductive Amination of Levulinic Acid Esters with Cyano Compounds
US 6,906,201 (2005)	Production of N-(methyl aryl)-2-lactam, N-(methyl cycloalkyl)-2-lactam and N-alkyl-2-lactam by reductive amination of lactones with aryl and alkyl cyano compounds
US 6,903,222 (2005)	Production of 5-methyl-N-aryl-2-pyrrolidone and 5-methyl-N-cycloalkyl-2- pyrrolidone by reductive amination of levulinic acid with aryl amines
US 6,900,337 (2005)	Production of 5-methyl-1-hydrocarbyl-2-pyrrolidone by reductive amination of levulinic acid
US 6,863,722 (2005)	Production of 5-methyl-n-aryl-2-pyrrolidone and 5-methyl-n-alkyl-2-pyrrolidone by reductive amination of levulinic acid with nitro compounds
US 6,855,731 (2005)	Production of 5-methyl-N-aryl-2-pyrrolidone and 5-methyl-N-alkyl-2-pyrrolidone by reductive amination of levulinic acid esters with nitro compounds
US 6,841,520 (2005)	Production of 5-methyl-N-aryl-2-pyrrolidone and 5-methyl-N-cycloalkyl-2- pyrrolidone by reductive amination of levulinic acid with cyano compounds
US 6,835,849 (2004)	Synthesis of alkenoate esters from lactones and alcohols
US 6,828,278 (2004)	Production of N-aryl-2-lactam and N-cycloalkyl-2-lactam by reductive amination of lactones with aryl amines
US 6,828,277 (2004)	Production of N-aryl-2-Lactam and N-Alkyl-2-Lacatam by reductive amination of lactones with aryl and alkyl nitro compounds
US 6,818,593 (2004)	Production of 5-methylene-N-aryl-2-pyrrolidone and 5-methyl-N-alkyl-2-pyrrolidone by reductive amination of levulinic acid with nitro compounds
US 6,720,459 (2004)	Continuous process for the preparation of polytrimethyleneether glycol
US 6,756,501 (2004)	Manufacture of 3-MethylTetrahydrofuran from alpha-Methylene-Gamma-Butyrolactone in a Single Step Process
US 6,743,819 (2004)	Production of 5-methyl-N-aryl-2-pyrrolidone and 5-methyl-N-cycloalkyl-2- pyrrolidone by reductive amination of levulinic acid with aryl amines

US 6,673,946 (2004)	Manufacture of 3-methyl-tetrahydrofuran from 2-methyl-butyrolactone
US 6,664,402 (2003)	Manufacture of 3-methyl-tetrahydrofuran from alpha-methylene-gamma-butyrolactone in a two step process
US 6,649,776 (2003)	Methylenelactone synthesis in supercritical fluids
US 6,617,464 (2003)	Production of 5-methylbutyrolactone from levulinic acid
US 6,593,481 (2003)	Hydrogenation of 3,4-tetrahydrofurandiol to tetrahydrofuran
US 6,232,474 (2001)	Process for the preparation of alpha-methylenelactones and alpha-substituted hydrocarbylidene lactones

Enzyme Catalysis

US 6,670,158 (2003)	Method for producing methacrylic acid and acrylic acid with a combination of enzyme catalysts
US 6,582,943 (2002)	Method for producing 2-hydroxyisobutyric acid and methacrylic acid from acetone cyanohydrin

Gas to Liquids (Fischer Tropsch)

US 6,313,318 (2001)	Process for the preparation of alpha-methylene lactones
US 6,759,439 (2004)	Fischer-Tropsch processes and catalysts with promoters
US 6,727,289 (2004)	Boron promoted catalysts and Fischer Tropsch processes
US 6,602,921 (2003)	Process for the preparation of hydrocarbons
US 6,489,371 (2002)	Fischer-Tropsch processes and catalysts with promoters
US 6,476,085 (2002)	Fischer-Tropsch processes using catalysts on mesoporous supports
US 6,368,997 (2002)	Fischer-Tropsch processes and catalysts using fluorided supports
US 6,365,544 (2002)	Fischer-Tropsch processes and catalysts using fluorided alumina supports
US 6,353,035 (2002)	Fischer-Tropsch processes using xerogel and aerogel catalysts by destabilizing aqueous colloids
US 6,333,294 (2001)	Fischer-Tropsch processes and catalysts with promoters
US 6,319,872 (2001)	Fischer-Tropsch processes using catalysts on mesoporous supports
US 6,235,677 (2001)	Fischer-Tropsch processes using xerogel and aerogel catalysts by destabilizing aqueous colloids

Isobutane Routes to p-Xylene

US 7,071,371 (2006)	Gel catalysts and methods for their use in catalytic dehydrogenation processes
US 7,067,708 (2006)	Process for the preparation of p-xylene
US 6,696,388 (2004)	Gel catalysts and process for preparing thereof
US 6,686,310 (2004)	High Surface Area Metal Oxide Catalysts Incorporating Metals and Metal Ions
US 6,600,081 (2003)	Process for the preparation of p-xylene
US 6,475,950 (2002)	Catalytic dehydrogenation processes and chromium catalysts for use therein

Environmentally Safer Phosgene and Thionyl chloride Catalysts

US 6,054,612 (2000)	Phosgene manufacturing process
US 6,054,107 (2000)	Phosgene manufacturing process
US 6,022,993 (2000)	Phosgene manufacturing process
US 5,879,652 (1999)	Process for producing oxochlorides of sulfur
US 5,759,508 (1998)	Process for producing oxochlorides of sulfur

Fluoromonomer Catalysis

US 6,706,935 (2004)	Catalytic equilibration to increase the relative mole fraction of CF3CHFCl, CF3CHCl2 or CF3CF2H in a composition
US 6,624,337 (2003)	Process for the manufacture of fluoroolefins

US 5,286,824 (1993)	Process for the preparation of halogenated 2,2-bis(trifluoromethyl)-1,3-dioxolanes
US 5,068,472 (1991)	Multistep synthesis of hexafluoropropylene
US 5,057,634 (1991)	Multistep synthesis of hexafluoropropylene
US 5,043,491 (1991)	Multistep synthesis of hexafluoropropylene

Chlorofluorocarbon Replacements

US 6,762,333 (2004)	Process for Reducing the Fluorine Content of Hydrofluorocarbons and Hydrohalofluorocarbons
US 6,281,396 (2001)	Fluorocarbon purification process
US 5,763,698 (1998)	Process for reducing the fluorine content of hydrofluorocarbons and hydrohalofluorocarbons
US 5,523,498 (1996)	Process for reducing the fluorine content of hydrofluorocarbons and hydrohalofluorocarbons
US 5,461,177 (1995)	Fluorocarbon purification process
US 5,345,016 (1994)	Manufacture of 1,1,1,2-tetrafluoroethane
US 5,302,765 (1994)	Catalytic process for producing CF3CHClF
US 5,261,948 (1993)	Carbon molecular sieve for the kinetic separation of acid gases and fluorocarbons
US 5,243,106 (1993)	Processes using aluminum fluoride catalyst compositions for preparing 1,1-dichloro-1,2,2,2-tetrafluoroethane
US 5,220,083 (1993)	Synthesis of perfluoropropane
US 5,243,108 (1993)	Aluminum fluoride catalyst compositions and use thereof in a chlorofluorination process for preparing 1,1-dichloro-1,2,2,2-tetrafluoroethane
US 5,185,482 (1993)	Manufacture of 1,1,1,2-tetrafluoroethane
US 5,177,224 (1993)	Process for the preparation of halogenated 2,2-bis(trifluoromethyl)-1,3-dioxolanes
US 5,120,883 (1992)	Catalytic process for producing CCl3CF3
US 5,094,773 (1992)	Azeotropes of HF and process for the separation of HF via azeotropic distillation
US 5,051,537 (1991)	Gas-phase fluorination
US 5,026,930 (1991)	Gas-phase fluorination process
US 5,008,476 (1991)	Process for the preparation of 1,1,1,2-tetrafluoroethane
US 5,008,475 (1991)	Gas-phase fluorination process
US 4,944,846 (1990)	Process for the separation of HF via Azeotropic distillation
US 4,935,558 (1990)	Reductive dechlorination of 1,1,1,2-tetrafluoro-2-chloroethane
US 4,922,037 (1990)	Gas-phase fluorination process
US 4,911,792 (1990)	Process for the separation of HF via phase separation and distillation
US 4,902,838 (1990)	Isomerization of saturated fluorohydrocarbons
US 4,843,181 (1989)	Process for the manufacture of 1,1,1-trifluorodichloroethane and 1,1,1,2-tetrafluorochloroethane
US 4,766,260 (1988)	Gas-phase fluorination process
US 4,766,259 (1988)	Gas-phase fluorination process

Homogeneous Catalysis

US 6,369,257 (2002)	Hydroformylation of olefins using supported bis(phosphorus) ligands
US 6,288,253 (2001)	Supported dendrimer catalyst
US 6,284,927 (2001)	Hydroperoxide decomposition process
US 6,229,052 (2001)	Hydroformylation of olefins using supported bis(phosphorus) ligands
US 4,057,565 (1977)	2-Dialkylaminobenzyl and 2-dialkylaminomethylphenyl derivatives of selected transition metals
US 4,042,610 (1977)	Process for preparing hydrocarbyl and silahydrocarbyl transition metal dihydrocarbylamides

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Scientific Seminars (1987-Present)

Approximately 20 seminars prior to 1987

1. "DuPont's Butane Oxidation Process to Maleic Anhydride", University of Waterloo, Waterloo, Ontario, Canada, November, 1987
2. "Potential Routes to HFC-134a", EPA Symposium on CFC Alternatives, Washington, DC, January 13, 1988
3. "Potential Routes to HFC-123", EPA Symposium on CFC Alternatives, Washington, DC, January 13, 1988
4. "Chlorofluorocarbon Manufacturing: Past, Present and Future?", Florida Catalysis Meeting, Palm Coast, FL, May 2-6, 1988
5. "Potential Routes to CFC Alternatives", Japanese Environmental Symposium, Tokyo, Japan, July 4-8, 1988
6. "The Ozone-CFC Issue: DuPont Leadership and the Race for Alternatives", University of Delaware, Newark, DE, October 3, 1988
7. "The Ozone-CFC Issue and the Race for Alternatives", Guelph University, Guelph, Ontario, Canada, November 21, 1988

8. "Catalytic Routes to CFC Alternatives", Regional ACS Meeting, Chicago, IL, January 20, 1989
9. "The Ozone-CFC Issue: DuPont Leadership and the Race for Alternatives", University of Indiana, Bloomington, IN, February 15, 1989
10. "The Ozone-CFC Issue: DuPont Leadership and the Race for Alternatives", Regional ACS/AIChE Meeting, Woodbury, NJ, March 14, 1989
11. "An Overview of Emerging Catalytic Technologies", Joint ACS- Mexico NSF Meeting, Cuernavaca, Mexico, May 23-25, 1989
12. "Industrial Progress on the Development of CFC Alternatives", European Conference on Fluorine Chemistry, Leicester, England, September 5, 1989
13. "The Ozone-CFC Issue and the Race for Alternatives", New Jersey High School Teachers Conference, Asbury Park, NJ, October 3, 1989
14. "New Opportunities in Catalysis Research", National Academy of Science, Washington, DC, October 30, 1989
15. "The Ozone-CFC Issue and the Race for Alternatives", National Meeting of the AIChE., San Francisco, CA, November 5-10, 1989
16. "The Ozone-CFC Issue and the Race for Alternatives", University of Waterloo, Waterloo, Ontario, Canada, November 21, 1989
17. "The Ozone-CFC Issue and the Race for Alternatives", Rutgers University, New Brunswick NJ, November 29, 1989
18. "The Ozone-CFC Issue and the Race for Alternatives", Regional Meeting of the AIChE, Ponca City, OK, December 5, 1989
19. "New Catalytic Systems for the Synthesis of CFC Alternatives", Northwestern University, Evanston, IL, February 2, 1990
20. "The Ozone-CFC Issue: The Challenges and Race for Alternatives", AAAS Symposium on CFCs and Atmospheric Science, New Orleans, LA, February 5-7, 1990
21. "The Ozone-CFC Issue: The Challenges and Race for Alternatives", Haldor Topsoe Co. Ltd., Lyngby Denmark, March 20, 1990
22. "The Ozone-CFC Issue: The Challenges and Race for Alternatives", Technical University, Twente, Netherlands, March 22, 1990
23. "The Ozone-CFC Issue: The Challenges and Race for Alternatives", Louvain-la-Neuve, Louvain Belgium, March 23, 1990
24. "The Ozone-CFC Issue: The Challenges and Race for Alternatives", Laboratoire de Catalyse, Namur, Belgium, March 26, 1990
25. "The Ozone-CFC Issue: The Challenges and Race for Alternatives", Technical University, Ghent, Belgium, March 27, 1990
26. "The Ozone-CFC Issue: The Challenges and Race for Alternatives", Catholique University of Leuven, Leuven, Belgium, March 28, 1990
27. "The Ozone-CFC Issue: The Challenges and Race for Alternatives", Technical University, Eindhoven, Netherlands, March 30, 1990
28. "The Ozone-CFC Issue: The Challenges and Race for Alternatives", Regional ASHRAE Meeting, Burlington, VT, June 6, 1990
29. "Recent Developments in the Catalytic Synthesis of CFC Alternatives", Gordon Conference on Catalysis, New London, NH, June 25-29, 1990
30. "Progress on the Development and Use of CFC Alternatives", ACS National Meeting, Washington, DC, August 29, 1990
31. "Recent Developments in the Catalytic Synthesis of CFC Alternatives", ARCO Symposium on Frontiers in Catalysis, Newtown Square, PA, March 25, 1990
32. "Recent Progress in the Development of CFC-Alternatives", Global Environment and Energy Issues Symposium, Fukuoka, Japan, November 21, 1990
33. "Opportunities for Catalysis and Process Research to Resolve Environmental Issues", Catalytica Symposium on Strategies for a Clean Environment, Las Vegas, NV, December 11-12, 1990
34. "Recent Developments in the Catalytic Synthesis of CFC Alternatives", Union Carbide Corp. Ltd., Boundbrook, NJ, January 10, 1990

35. "Recent Developments in the Catalytic Synthesis of CFC Alternatives", University of Pittsburgh, Pittsburgh, PA, January 17, 1991
36. "Recent Developments in the Catalytic Synthesis of CFC Alternatives", University of British Columbia, Vancouver, BC, Canada, January 22, 1991
37. "Recent Developments in the Catalytic Synthesis of CFC Alternatives", Simon Frazer University, Burnaby BC, Canada, January 23, 1991
38. "Recent Developments in the Catalytic Synthesis of CFC Alternatives", University of Victoria, Victoria BC, Canada, January 24, 1991
39. "Recent Developments in the Catalytic Synthesis of CFC Alternatives", W. R. Grace Co., Bethusda, MD, March 4, 1991
40. "Recent Developments in the Catalytic Synthesis of CFC Alternatives", The Global Business Outlook for CFC-Alternatives, London England, March 12-13, 1991
41. "Evaluation of Surface and Lattice Oxygen Capacity in Metal Oxide Catalysts for Propylene Oxidation to Acrolein using the TAP Reactor System", Third European Workshop on Selective Oxidations by Heterogeneous Catalysts, Louvain-la-Neuve, Belgium, April 8-10, 1991
42. "Recent Developments in the Catalytic Synthesis of CFC Alternatives", Institut Lebel at Strasbourg, Strasbourg, France, April 15, 1991
43. "Recent Developments in the Catalytic Synthesis of CFC Alternatives", Institut de Recherches sur la Catalyse, Lyon, France, April 18, 1991
44. "An Overview of the Ozone-CFC Issue", A. I. DuPont Children's Hospital, Wilmington, DE, April 30, 1991
45. "Quantitative Discrimination for Benzene Oxidation to Maleic Anhydride Using the TAP Reactor System", North American Catalysis Society Meeting, Lexington, KY, May 4-7, 1991
46. "Recent Developments in the Catalytic Synthesis of CFC Alternatives", North American Catalysis Society Meeting, Lexington, KY, May 4-7, 1991
47. "The Commercial Development of CFC-Alternatives", National Meeting of the ACS, New York, NY, August 28, 1991
48. "Perclene-Based Routes to HFC-134a (CF3CH2F): An Environmentally Friendly Replacement for CFC-12", International Symposium on Fluorine Chemistry, Bochum, Germany, September 1-6, 1991
49. "Recent Developments in the Catalytic Synthesis of CFC Alternatives", Princeton University, Princeton NJ, October 22, 1991
50. "The Role of Catalysis in the Development of CFC Alternatives", Pittsburgh Catalysis Society Meeting, Pittsburgh, PA, November 6, 1991
51. "Kinetics of Chlorofluorocarbon Disproportionations: A TAP Reactor Study", Annual AIChE. Mtg, Los Angeles CA, November 25-29, 1991
52. "Recent Developments in the Catalytic Synthesis of CFC Alternatives", Virginia Polytechnic University, Blacksburg, VA, December 5, 1991
53. "Recent Developments in the Catalytic Synthesis of CFC Alternatives", University of Houston, January 31, 1992
54. "Protecting the Ozone Layer: CFC Alternatives", Symposium on Catalysis for the Protection of the Environment, AAAS Meeting, Chicago, IL, February 7, 1992
55. "The Role of Catalysis in the Development of CFC Alternatives", J. Wolfgang Goethe-Universitat, Frankfurt, Germany, March 4, 1992
56. "The Role of Catalysis in the Development of CFC Alternatives", Institut fur Technische Chemie, Aachen, Germany, March 10, 1992
57. "The Role of Catalysis in the Development of CFC Alternatives", Phys.-Chem. Institut, Universitat Munchen, Munich, Germany March 11, 1992
58. "Catalysis: A DuPont Core Competency", Commercial Development Association Annual Meeting, Chicago IL, March 22-24, 1992
59. "Catalysis: Technology for Environmentally Safer Processes", ACS National Meeting, San Francisco, CA, April 7,1992

60. "The Role of Catalysis in the Development of CFC Alternatives", Surface Science and Catalysis Science Symposium, Lawrence Berkeley Laboratory, University of California, Berkeley, CA, April 9, 1992
61. "Recent Developments in the Catalytic Synthesis of CFC Alternatives", University of Minnesota, April 21, 1992
62. "Catalysis: Key to Protecting the Ozone Layer", 14th Conference on Catalysis of Organic Reactions, Albuquerque, NM, April 27-29, 1992
63. "Catalysis: a Critical Technology for the Development of CFC Alternatives", Philadelphia Catalysis Society Spring Symposium, Newark, DE, May 6, 1992
64. "An Overview of the CFC–Alternatives Commercialization Program", 22nd International Thermal Condensation Conference, University of Delaware, Newark, DE, July 5-10, 1992
65. "Kinetics of the Redox Reactions of the O2:Propylene: □-Bismuth Molybdate System", 10th International Congress on Catalysis, Budapest, Hungary, July 19-24, 1992
66. "Toward Catalysis and Process R&D in the 21st Century Chemical Industry", 10th International Congress on Catalysis, Budapest, Hungary, July 17-24, 1992
67. "Catalysis: Technology for Environmentally Safer Processes" CHEMRAWN VIII, Moscow, Russia, September 7-9, 1992
68. "Protecting the Ozone Layer: The Search for Solutions", Delaware Academy of Science, University of Delaware, Newark, DE, November 17, 1992
69. "Protecting the Ozone Layer: The Search for Solutions", Ninth National Meeting of the Royal Australian Chemical Society, Melbourne, Australia, December 7-11, 1992
70. "The Role of Catalysis in the Development of CFC Alternatives", Ninth National Meeting of the Royal Australian Chemical Society, Solid State Division, Melbourne, Australia, December 7-11, 1992
71. "An Overview of the Ozone-CFC Issue", Ninth National Meeting of the Royal Australian Chemical Society, Chemical Education Div., Melbourne, Australia, December 7-11, 1992
72. "Catalysis: Technology for Environmentally Safer Processes", University of New South Wales, Sydney, Australia, December 15, 1992
73. "Catalysis: Technology for Environmentally Safer Processes", Northwestern University, Evanston IL, January 15, 1993
74. "Protecting the Ozone Layer: The Search for Solutions", Del ChemVets, Wilmington, DE, January 19, 1993
75. "Catalysis: A Critical Technology for the Development of Alternatives to CFCs", Michigan Catalysis Society, Dearborn, MI, February 2, 1993
76. "The Role of Catalysis in the Development of CFC Alternatives", Iowa State University, Ames, IA, March 25, 1993
77. "Protecting the Ozone Layer: The Search for Solutions", Almquist Lecture, University of Idaho, Moscow, ID, April 24, 1993
78. "HFCs and HCFCs: More Costly Solutions to CFCs", Intertech Conference, Boston MA, June 15, 1993
79. "Inorganic Materials: Their Role in the Development of CFC Alternatives", Inorganic Gordon Conference, July 26-30, 1993, Wolfesboro, NH
80. "Future Needs in Homogeneous Catalysis for Industrial Development", US-Former Soviet Union Workshop on Organometallic Chemistry and Catalysis, Northwestern University, Evanston, Ill, August 18-21, 1993
81. "Catalysts for CFC Hydrodechlorinations", National ACS Meeting, Chicago Ill, August 26, 1993
82. "Catalysis and Chemistry for Cleaner Processes", National ACS Meeting, Chicago Ill, August 26, 1993
83. "CFC Phaseout: The End of One Era and the Beginning of Another", Indiana University, Bloomington IN, November 17, 1993
84. "Inorganic Materials: Their Role in the Development of CFC Alternatives", 26th Inorganic Discussion Weekend, Guelph University, Guelph ONT., November 19-21, 1993

85. "Environmentally-Safer Processes: Opportunities for Catalysis and Process Research", Air Products Co. Catalysis Seminar Series, November 30, 1993
86. "Environmental Challenges Facing the Chemical Industry", US-Russia Workshop on Environmental Catalysis, Wilmington DE., January 14-16, (1994)
87. "CFC Phaseout: The End of One Era and the Beginning of Another", Tulane University, New Orleans, LA, February 4, 1994
88. "The Role of Catalysts in the Development of CFC Alternatives", ACS Meeting, San Diego, March 13-18, (1994)
89. "Recent DuPont Examples of Environmentally Benign Processing", ACS Meeting, San Diego, CA, March 13-18, (1994)
90. "Chemical Manufacturing in the 21st Century: Challenges and Opportunities for Catalysis and Process Research" NIST Advances Technology Program, Gaithersburg, MA, April 29, 1994
91. "DuPont's THF Process: New Frontiers in Catalytic Oxidation, Hydrogenation and Reactor Engineering", Council for Chemical Research Conference on Frontiers in Catalysis, Palm Springs, CA, May 22-25, 1994"
92. "Environmental Challenges and Opportunities Facing the Chemical Industry in the 21st Century", ARCO Symposium on Environmentally Benign Processing, Newtown Square, PA, June 17, 1994
93. "Chemical Manufacturing in the 21st Century: Challenges and Opportunities for Catalysis and Process Research", J. Wolfgang Goethe-Universitat, Frankfurt, Germany, July 8, 1994
94. "Environmental Challenges and Opportunities Facing the Chemical Industry in the 21st Century", Roermond Conference on Catalysis, Kerkrade, Netherlands, July 10-15 (1993)
95. "The Role of Catalysts in the Development of CFC Alternatives" 46th South East Regional ACS Meeting-Symposium on CFC Alternatives, Birmingham, AL, October 16-19 (1994)
96. "Environmental Challenges and Opportunities Facing the Chemical Industry in the 21st Century" 46th South East Regional ACS Meeting-Symposium Green Processes, Birmingham, AL, October 16-19 (1994)
97. "Hazardous Materials Management", NIST/CCR Workshop on Research Opportunities in Pollution Prevention for Chemists and Chemical Engineers: An Industrial Perspective, Gaithersburg, MD., October 24-25, 1994
98. "Environmental Challenges and Opportunities Facing the Chemical Industry in the 21st Century", California Catalysis Society, San Francisco, CA, December 5, 1994
99. "CFC Phaseout: The End of One Era and the Beginning of Another", Carnegie Mellon Institute, Pittsburgh, PA, January 13, 1995
100. "Environmental Challenges and Opportunities Facing the Chemical Industry in the 21st Century", Pittsburgh University, Pittsburgh, PA, January 14, 1995
101. "Toward Environmentally Benign Chemical Manufacturing", National Research Council of Canada, Ottawa ONT., March 15, 1995
102. "CFC Phaseout: The End of One Era and the Beginning of Another", University of Western Ontario, London ONT., March 16, 1995
103. "Chemical Manufacturing in the 21st Century: Challenges and Opportunities for Catalysis and Process Research", University of Pennsylvania, March 27, 1995
104. "Catalysts and Inorganic Chemistry", Barnes Award Address, ACS National Meeting, Anaheim, CA, April 4, 1995
105. "The Commercial Development of CFC Alternatives: A Modern Day Manhattan Project", MIT, Boston, MA, April 18, 1995
106. "Environmental Challenges and Opportunities Facing the Chemical Industry in the 21st Century", Florida Catalysis Conference, April 24-28, 1995
107. "Toward Environmentally Benign Chemical Manufacturing", Pittsburgh, PA., May 17, 1995

108. "A Catalytic Process For the Recycle of CFCs", 14th North American Catalysis Conference, Snow Bird, UT, June 12-16, 1995
109. "Chlorine Use In The Chemical Industry", 14th North American Catalysis Conference, Snow Bird, UT, June 12-16, 1995
110. "CFC-Alternatives: A Challenging Opportunity For New Materials", VII International Conference on Advanced Materials, Cancun, Mexico, August 27-September 1, 1995
111. "Environmental Catalysis: Challenges and Opportunities", Southwest Catalysis Society Meeting, Houston TX, November 9, 1995
112. "Toward Environmentally Benign Chemical Processing", University of Virginia, Charlottesville VA, November 3, 1995
113. "Toward Environmentally Benign Chemical Processing", The Catalysis Society of Metropolitan New York, Somerset NJ, November 16, 1995
114. "The Commercial Development of Chlorofluorocarbon CFC Alternatives" Ohio State University, Columbus OH, May 6, 1996
115. "The Environmental Challenge: Exciting New Opportunities for Catalytic Science and Engineering", Ohio State University, Columbus OH, May 7, 1996
116. "Determination of Kinetic Parameters for the Reaction of Hydrodechlorination of 1,1-dichlorotetrafluoroethane (CF3-CFCl2) over Pd Catalysts", H. Ribeiro, G. A. Somorjai Lawrence Berkeley National Laboratory, 1 Cyclotron Rd., Berkeley , CA 94720, C. S. Kellner, L. E. Manzer, and L. Abrams, E.I. DuPont Co., Experimental Station, Central Research and Development, Corporate Catalysis Center, Wilmington, DE 19880, California Catalysis Society, June 3, (1996)
117. "The Environmental Challenge: Exciting New Opportunities for Catalytic Science and Engineering", International Symposium on Surface Nano-Control of Environment Catalysts and Related Materials, Tokyo, Japan, November 25-27 (1996)
118. "The Development of Chlorofluorocarbon Alternatives", University of West Virginia, Morgantown VA, October 8, 1996)
119. "New Frontiers in Catalytic Science and Engineering: DuPont's New Tetrahydrofuran (THF) Process ", American Association for the Advancement of Science, Seattle WN, February 13, 1997
120. "Environmental Catalysis: Challenges and Opportunities", Worcester Polytechnical Institute, March 3, 1997
121. "Opportunities For Inorganic Materials in Industry: Part 1. The Development of CFC Alternatives", University of Illinois, April, 1997
122. " Opportunities For Inorganic Materials in Industry: Part II. Environmental Catalysis", University of Illinois, April, 1997
123. "Solving Environmental Problems Through Catalysis", 15th North American Catalysis Society Meeting, Chicago Ill, May 18-23, 1997
124. "Determination of Kinetic Parameters and Structure Sensitivity for the Hydrodechlorination of 1,1-Dichlorotetrafluoroethane (CF3CFCl2) over Pd Catalysts", 15th North American Catalysis Society Meeting, Chicago Ill, May 18-23, 1997
125. "Improved Phosgene Manufacturing Process", 15th North American Catalysis Society Meeting, Chicago Ill, May 18-23, 1997
126. "Heterogeneous Catalytic Hydrogenation of Chlorofluorocarbons", Presidential Green Chemistry Symposium, Washington DC, June 23-24 (1997)
127. "The Environmental Movement: New Opportunities for Catalytic Science and Engineering" Gordon Conference on Environmental Benign Chemical Synthesis, Oxford England, August 17-22, 1997
128. "Model Catalysts as the Standard For Industry", 214th ACS Meeting, Las Vegas, NV., September 7-11, (1997)
129. "Solving Environmental Problems Through Catalysis", Environmentally Benign Chemical Processing Workshop, June 12-14, 1998, University of Virginia, Charlottesville, Virginia
130. "Environmental Catalysis: Challenging New Opportunities for Catalysis", University of British Columbia, Vancouver BC, December 7, 1998

131. "Environmental Catalysis: Challenging New Opportunities for Catalysis", University of Alberta, Edmonton Alberta, December 8, 1998
132. "Environmental Catalysis: Challenging New Opportunities for Catalysis", University of Saskatchewan, Saskatoon, Saskatchewan, December 9, 1998
133. "Environmental Catalysis: Challenging New Opportunities for Catalysis", Laval University, Quebec City Quebec, February 7, 1999
134. "Environmental Catalysis: Challenging New Opportunities for Catalysis", University of New Brunswich, Fredericton NB, February 7, 1999
135. "Environmental Catalysis: Challenging New Opportunities for Catalysis", University of Toronto, Toronto ONT, February 7, 1999
136. "Environmental Chemistry: Challenging New Opportunities", University of Massachusetts, March 12, 1999
137. "Reduction of CO2 Emissions: An Opportunity for New Processes, DOE Workshop on Carbon Management, Sante Fe, NM April 29 (1999)
138. "Reduction of CO2 Emissions: An Opportunity for New Processes", ACS Symposium on CO2 Conversion and Utilization in Refinery and Chemical Processing, ACS Meeting, San Francisco, CA, March 26-31 (2000)
139. "A New Catalyst for an Old Process Driven by Environmental Concerns", 12th International Congress on Catalysis, Granada Spain, July 9-14 (2000)
140. "Managing Carbon Losses Through Selective Oxidation Catalysis", NRC Workshop on Carbon Management: Implications for R&D in the Chemical Sciences, Washington, DC, December 9-10, 2000
141. "Novel Oxyfluorination Routes to Fluoroaromatics, Alkanes and Olefins", 17th North American Catalysis Society Meeting, Toronto, Ontario, Canada, June 3-8, 2001
142. "Catalytic Synthesis of Fluorocarbons: Past Present and Future", Eugene Houdry Award Lecture, 17th North American Catalysis Society Meeting, Toronto, Ontario, Canada, June 3-8, 2001
143. "Global Warming and Selective Oxidation Catalysis", Tristate Catalysis Society Meeting, Cincinnati, Ohio, April 17-18, 2000
144. "A New Waste-Free Process for the Synthesis of Fluoroaromatics", Europacat V , Limerick, Ireland, September 3-7, 2001
145. "Catalytic Synthesis of Fluorocarbons: Past Present and Future", Queen's University, Kingston, Ontario, Canada, March 14, 2002
146. "Catalytic Synthesis of Fluorocarbons: Past Present and Future", Chicago Catalysis Society Meeting, Chicago, Ill, April 8, 2002
147. "An Overview of the Commercial Development of Chlorofluorocarbon (CFC) Replacements", Green Workshop, Venice, Italy September 8-14, 2002
148. E. V. Murphree Award Lecture, "Biomass Derivatives: A Sustainable Source of Chemicals", 226th ACS Meeting, New Orleans, March 25th , 2003
149. "Development and Application of Novel High-Throughput and Parallel Reactor Systems for Discovery of Gas-Phase Heterogeneous Catalysts" P. A. Mills, L. E. Manzer and J. F. Nicole, AIChE Meeting, Indianapolis, IN, Nov 4, 2002
150. "Biomass Derivatives: A Sustainable Source of Chemicals", Case Western Reserve, Cleveland OH, April 14, 2003
151. "Biomass Derivatives: A Sustainable Source of Chemicals", Philadelphia Catalysis Society Spring Symposium, Newark Delware, May 30, 2003
152. "Biomass Derivatives: A Sustainable Source of Chemicals", Southwest Catalysis Society, Oklahoma City, OK, Oct 24,2003
153. "DuPont Catalytic Science and Engineering: Past, Present and Future", AIChE Meeting, San Francisco, CA November 19, 2003
154. "Green Chemistry Process Alternatives for THF Manufacture", AIChE Meeting, San Francisco, CA November 19, 2003
155. "Industrial Opportunities for the Catalytic Conversion of Biomass Derivatives", Pacific Northwest Laboratory, December 10, 2003

156. Tarrant Distinguished Visiting Professor of Organic Chemistry, University of Florida, "Biomass Derivatives: A Sustainable Source of Chemicals", February 2004
157. Tarrant Distinguished Visiting Professor of Organic Chemistry, University of Florida, "Catalytic Synthesis of Fluorocarbons: Past Present and Future", February 2004
158. Tarrant Distinguished Visiting Professor of Organic Chemistry, University of Florida, "Reducing CO2 Emissions Through Selective Oxidation Catalysis", February 2004
159. "Industrial Opportunities for the Catalytic Conversion of Biomass Derivatives", Dutch Catalysis Society, Netherlands, March 8, 2004
160. "Biomass Derivatives: Industrially Important Applications" 227th American Chemical Society National Meeting, Anaheim, CA, March 28-April 1, 2004
161. "Industrial Opportunities for the Catalytic Conversion of Biomass Derivatives: A Case Study Based on Levulinic Acid", Dept of Energy Workshop on Biorenewables, April 12-14, 2004, Washington, DC
162. "Industrial Opportunities for the Catalytic Conversion of Biomass Derivatives: A Case Study Based on Levulinic Acid", University of Massachusetts, Amherst, MA, May 11, 2004
163. "Biomass Derivatives: New Opportunities for Chemical Catalysis", US-Netherlands Catalysis Conference, Philadelphia PA, August 19-20, 2004
164. "Biomass Derivatives: New Opportunities for Chemical Catalysis", Georgia Tech, Atlanta Georgia, October 13, 2004
165. "Synthesis of Methyl-alpha-Methylenebutyrolactone in Supercritical Carbon Dioxide", 2004 Annual AIChE Meeting, November 7-12, 2004, Austin, Texas
166. "Biomass Derivatives: New Opportunities for Chemical Catalysis", 229th American Chemical Society National Meeting, San Diego, CA, March 13-17, 2005
167. "Synthesis of Methyl-alpha-Methylenebutyrolactone in Supercritical Carbon Dioxide", International Symposium on Supercritical Fluids, May 1-5, 2005, Orlando, Florida
168. "Biomass Conversion: New Opportunities for Chemical Catalysis", 19th North American Catalysis Society Meeting, May 23-27, 2005, Philadelphia, PA
169. "Fundamental Catalyst Studies for the Base Catalyzed Reaction of GVL to MeMBL", 19th North American Catalysis Society Meeting, May 23-27, 2005, Philadelphia, PA
170. "Synthesis of γ-Methyl- γ-Methylene- γ-ButyroLactone in Supercritical CO_2", 19th North American Catalysis Society Meeting, May 23-27, 2005, Philadelphia, PA
171. "Toward a Sustainable Economy: Conversion of Biomass to Chemicals and Fuels", 19th Canadian Symposium on Catalysis, Saskatoon, Saskatchewan, Canada
172. "Toward a Sustainable Economy: Conversion of Biomass to Chemicals and Fuels" June 28, 2006, ExxonMobil R&D,Clinton NJ
173. "Toward a Sustainable Economy: Conversion of Biomass to Chemicals and Fuels" Chicago Catalysis Club, March 12, 2007, Chicago Illinois
174. "Renewable Fuels: New Opportunities for Catalysis and Process Research", 233rd Meeting of the American Chemical Society, March 23rd, 2007 Chicago Illinois
175. "The Impact of Renewable Feedstocks on Chemical Processes", 233rd Meeting of the American Chemical Society, March 24rd, 2007 Chicago Illinois
176. "Renewable Fuels and Chemicals: New Opportunities for Catalysis and Process Research", Biomass '07: Power, Fuels and Chemicals Workshop, EERC, University of North Dakota, May 15-16, 2007, Grand Forks, North Dakota
177. "Renewable Fuels and Chemicals: New Opportunities for Catalysis and Process Research", Symposium on Environmental Catalysts and Biomass Processes, Catalysis Research Center, Hokkaido University, July 13-14, 2007, Hokkaido, Japan
178. "New Opportunities for Catalysis: Biomass to Renewable Fuels and Chemicals", Philadelphia Catalysis Club, January 17th, 2008, Wilmington, Delaware
179. "New Opportunities for Catalysis: Biomass to Renewable Fuels and Chemicals", Kansas State University, September 17, 2008
180. "Recent Developments in the Conversion of Biomass to Renewable Fuels and Chemicals", March 22, 3009, ACS Meeting, Salt Lake City, Utah.

181. “Recent Developments in the Conversion of Biomass to Renewable Fuels and Chemicals”, May 5, 2009, Argonne National Laboratory, Illinois
182. “Recent Developments in the Conversion of Biomass to Renewable Fuels and Chemicals”, October 27, 2009, Delaware Division of the American Chemical Society, Wilmington DE
183. “Recent Developments in the Conversion of Biomass to Renewable Fuels and Chemicals”, March 14, 2010, ORCS Meeting, Monterey California
184. “Recent Developments in the Conversion of Biomass to Renewable Fuels and Chemicals”, August 4, 2010, PIRE Summer School Kloster Seeon, Germany
185. “Recent Developments in the Conversion of Biomass to Renewable Fuels and Chemicals”, December 15, 2010, PACRIM Meeting of the ACS, Honolulu, Hawaii