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- (71) Applicant: CHEVRON U.S.A. INC. [US/US]; 6001
Bollinger Canyon Road, San Ramon, California 94583
(US).
- (72) Inventor: XIE, Dan; 6001 Bollinger Canyon Road, San
Ramon, California 94583 (US).
- (74) Agents: FLAHERTY, Terrence M. et al.; Chevron Cor-
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94583-0806 (US).
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(54) Title: SYNTHESIS OF MOLECULAR SIEVE SSZ-105

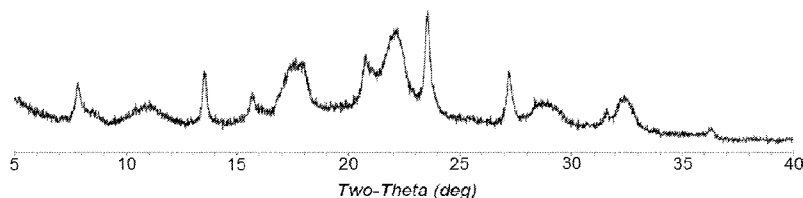


FIG. 1

(57) Abstract: A method is disclosed for synthesizing molecular sieve material designated SSZ-105 using N-methyl quinuclidinium cations or N,N'-dimethyl-1,4-diazabicyclo[2.2.2]octane dications as a structure directing agent. SSZ-105 is a disordered aluminosilicate molecular sieve comprising at least one intergrown phase of an ERI framework type molecular sieve and an LEV framework type molecular sieve.

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SYNTHESIS OF MOLECULAR SIEVE SSZ-105

TECHNICAL FIELD

[001] This disclosure relates to a method for preparing molecular sieve SSZ-105 using *N*-methyl quinuclidinium cations or *N,N'*-dimethyl-1,4-diazabicyclo[2.2.2]octane dications as a structure directing agent.

BACKGROUND

[002] Molecular sieve materials, both natural and synthetic, have been demonstrated in the past to be useful as adsorbents and to have catalytic properties for various types of organic conversion reactions. Certain molecular sieves, such as zeolites, aluminophosphates, and mesoporous materials, are ordered, porous crystalline materials having a definite crystalline structure as determined by X-ray diffraction. Within the crystalline molecular sieve material there are a large number of cavities which may be interconnected by a number of channels or pores. These cavities and pores are uniform in size within a specific molecular sieve material. Because the dimensions of these pores are such as to accept for adsorption molecules of certain dimensions while rejecting those of larger dimensions, these materials have come to be known as "molecular sieves" and are utilized in a variety of industrial processes.

[003] Although many different crystalline molecular sieves have been discovered, there is a continuing need for new molecular sieves with desirable properties for gas separation and drying, organic conversion reactions, and other applications. New molecular sieves can contain novel internal pore architectures, providing enhanced selectivities in these processes.

[004] Molecular sieves are classified by the Structure Commission of the International Zeolite Association according to the rules of the IUPAC Commission on Zeolite Nomenclature. According to this classification, framework type zeolites and

other crystalline microporous molecular sieves, for which a structure has been established, are assigned a three letter code and are described in the "*Atlas of Zeolite Framework Types*," Sixth Revised Edition, Elsevier, 2007.

[005] Molecular sieves may be ordered or disordered. Ordered molecular sieves are built from structurally invariant building units, called Period Building Units (PerBUs), and are periodically ordered in three dimensions. Crystal structures built from PerBUs are called end-member structures if periodic ordering is achieved in all three dimensions. Disordered structures, on the other hand, show periodic ordering in less than three dimensions. One such disordered structure is a disordered planar intergrowth in which the building units from more than one framework type are present. Such intergrowths frequently have significantly different catalytic properties from their end members. For example, zeolite ZSM-34 is well known intergrowth of ERI and OFF framework types and exhibits a methanol-to-olefins performance superior to that of its individual component materials.

[006] U.S. Patent Application Nos. 14/884,845 and 14/884,859 (filed October 16, 2015) disclose an ERI/LEV intergrowth molecular sieve designated SSZ-105 and its synthesis using *N,N*-dimethylpiperidinium cations as a structure directing agent.

[007] It has now been found that *N*-methyl quinuclidinium cations and *N,N'*-dimethyl-1,4-diazabicyclo[2.2.2]octane dications are effective as structure directing agents in the synthesis of SSZ-105.

SUMMARY

[008] The present disclosure is directed to a method for preparing a new family of crystalline molecular sieves with unique properties, referred to herein as "molecular sieve SSZ-105" or simply "SSZ-105." Molecular sieve SSZ-105 comprises at least one intergrown phase of an ERI framework type molecular sieve and an LEV framework type molecular sieve.

[009] In one aspect, there is provided a method for preparing an aluminosilicate molecular sieve material comprising at least one intergrown phase comprising an ERI framework type molecular sieve and an LEV framework type molecular sieve, the method comprising: (a) preparing a reaction mixture containing: (1) at least one source of silicon oxide; (2) at least one source of aluminum oxide; (3) at least one source of a Group 1 metal (M), wherein M is selected from the group consisting of potassium and combinations of sodium and potassium; (4) hydroxide ions; (5) a structure directing agent selected from the group consisting of *N*-methyl quinuclidinium cations, *N,N'*-dimethyl-1,4-diazabicyclo[2.2.2]octane dications, and combinations thereof; and (6) water; and (b) subjecting the reaction mixture to crystallization conditions sufficient to form crystals of the molecular sieve material.

[010] In another aspect, there is provided an aluminosilicate molecular sieve material comprising at least one intergrown phase comprising an ERI framework type molecular sieve and an LEV framework type molecular sieve, wherein the molecular sieve material has, in its as-synthesized and anhydrous form, a composition, in terms of mole ratios, comprising the following:

	Broad	Exemplary
$\text{SiO}_2/\text{Al}_2\text{O}_3$	5 to 50	10 to 25
Q/SiO_2	0.02 to 0.20	0.05 to 0.20
M/SiO_2	0.01 to 0.20	0.02 to 0.15

wherein Q is selected from the group consisting of *N*-methyl quinuclidinium cations, *N,N'*-dimethyl-1,4-diazabicyclo[2.2.2]octane dications, and combinations thereof; and M is a Group 1 metal selected from the group consisting of potassium and combinations of sodium and potassium.

BRIEF DESCRIPTION OF THE DRAWINGS

[011] FIG. 1 is a powder X-ray diffraction (XRD) pattern of the as-synthesized molecular sieve prepared in Example 1.

[012] FIG. 2 is a Scanning Electron Micrograph (SEM) image of the as-synthesized molecular sieve prepared in Example 1.

[013] FIG. 3 is a plot of several DIFFaX-generated simulated XRD patterns and a powder XRD pattern of the calcined form of the molecular sieve prepared in Example 1.

[014] FIG. 4 is a plot of several DIFFaX-generated simulated XRD patterns and a powder XRD pattern of the calcined form of the molecular sieve prepared in Example 2.

[015] FIG. 5 is a plot of several DIFFaX-generated simulated XRD patterns and a powder XRD pattern of the calcined form of the molecular sieve prepared in Example 3.

[016] FIG. 6 is a plot of several DIFFaX-generated simulated XRD patterns and a powder XRD pattern of the calcined form of the molecular sieve prepared in Example 4.

[017] FIG. 7 is a plot of several DIFFaX-generated simulated XRD patterns and a powder XRD pattern of the calcined form of the molecular sieve prepared in Example 5.

[018] FIG. 8 is a plot of several DIFFaX-generated simulated XRD patterns and a powder XRD pattern of the calcined form of the molecular sieve prepared in Example 6.

DETAILED DESCRIPTION

Introduction

[019] The following terms will be used throughout the specification and will have the following meanings unless otherwise indicated.

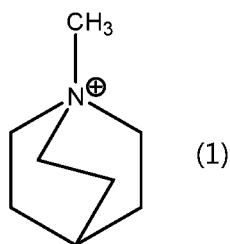
[020] The term "framework type" is used in the sense described in the *"Atlas of Zeolite Framework Types,"* Sixth Revised Edition, Elsevier, 2007.

[021] As used herein, the numbering scheme for the Periodic Table Groups is as disclosed in *Chem. Eng. News*, 63(5), 26-27 (1985).

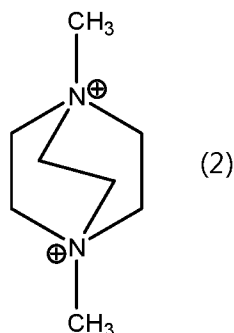
[022] Intergrown molecular sieve phases are disordered planar intergrowths of molecular sieve frameworks. Reference is directed to the *"Catalog of Disordered Zeolite Structures,"* 2000 Edition, published by the Structure Commission of the International Zeolite Association and to the *"Collection of Simulated XRD Powder Patterns for Zeolites,"* Fifth Revised Edition, Elsevier, 2007, published on behalf of the Structure Commission of the International Zeolite Association for a detailed explanation on intergrown molecular sieve phases.

[023] The molecular sieves described herein are disordered planar intergrowths of end-member structures ERI and LEV. Both of these two framework types belong to the group that has double 6-rings (*d6r*) as secondary building units. Intergrown ERI/LEV molecular sieves comprise regions of ERI framework type sequences and regions of LEV framework type sequences. Each change from an ERI to an LEV framework type sequence results in a stacking fault.

[024] In preparing molecular sieve SSZ-105, *N*-methyl quinuclidinium cations or *N,N'*-dimethyl-1,4-diazabicyclo[2.2.2]octane dications are used as a structure directing agent, also known as a crystallization template. The structure directing agents useful for making SSZ-105 are represented by the following structures (1) and (2):



N-methyl quinuclidinium cation



N,N'-dimethyl-1,4-diazabicyclo[2.2.2]octane dication

[025] The cationic structure directing agent is associated with anions which may be any anion that is not detrimental to the formation of SSZ-105. Representative anions include elements from Group 17 of the Periodic Table (e.g., fluoride, chloride, bromide and iodide), hydroxide, sulfate, tetrafluoroborate, acetate, carboxylate, and the like.

Reaction Mixture

[026] In general, molecular sieve SSZ-105 is prepared by: (a) preparing a reaction mixture containing (1) at least one source of silicon oxide; (2) at least one source of aluminum oxide; (3) at least one source of a Group 1 metal (M), wherein M is selected from the group consisting of potassium and combinations of sodium and potassium; (4) hydroxide ions; (5) a structure directing agent selected from the group consisting of *N*-methyl quinuclidinium cations, *N,N'*-dimethyl-1,4-diazabicyclo[2.2.2]octane dications, and combinations thereof; and (6) water; and (b) subjecting the reaction mixture to crystallization conditions sufficient to form crystals of the molecular sieve.

[027] The composition of the reaction mixture from which the molecular sieve is formed, in terms of mole ratios, is identified in Table 1 below:

TABLE 1

Components	Broad	Exemplary
SiO ₂ /Al ₂ O ₃	10 to 100	15 to 80
M/SiO ₂	0.05 to 1.00	0.15 to 0.45
Q/SiO ₂	0.05 to 0.60	0.15 to 0.40
OH/SiO ₂	0.10 to 1.00	0.40 to 0.95
H ₂ O/SiO ₂	10 to 100	15 to 40

wherein compositional variables M and Q are as described herein above.

[028] Sources useful herein for silicon oxide include fumed silica, precipitated silicates, silica hydrogel, silicic acid, colloidal silica, tetra-alkyl orthosilicates (e.g., tetraethyl orthosilicate), and silica hydroxides.

[029] Sources useful herein for aluminum oxide include aluminates, alumina, and aluminum compounds (e.g., aluminum chloride, aluminum hydroxide, and aluminum sulfate), kaolin clays, and other zeolites (e.g., zeolite Y).

[030] In the present synthesis method, the Group 1 metal (M) is selected from the group consisting of potassium and combinations of sodium and potassium. The sodium source may be sodium hydroxide. The potassium source may be potassium hydroxide. In embodiments when the Group 1 metal (M) is a mixture of sodium and potassium, the molar ratio of sodium (m_1) divided by the molar ratio of potassium (m_2) in the reaction mixture is less than or equal to 2.0; or less than or equal to 1.0; preferably, in the range from 0.1 to 2.0; and conveniently, in the range from 0.1 to 0.5.

[031] Optionally, the reaction mixture may also include seeds of a molecular sieve material, such as SSZ-105 crystals from a previous synthesis, in an amount of from 0.1 to 10 wt. % or from 0.5 to 5 wt. % of the reaction mixture.

[032] For each embodiment described herein, the molecular sieve reaction mixture can be supplied by more than one source. Also, two or more reaction components can be provided by one source.

[033] The reaction mixture can be prepared either batch wise or continuously. Crystal size, morphology and crystallization time of the molecular sieve described herein can vary with the nature of the reaction mixture and the crystallization conditions.

Crystallization and Post-Synthesis Treatment

[034] Crystallization of the molecular sieve disclosed herein can be carried out under either static, tumbled or stirred conditions in a suitable reactor vessel, such as for example polypropylene jars or Teflon-lined or stainless steel autoclaves, at a temperature of from 125°C to 200°C (e.g., from 130°C to 160°C) for a time sufficient for crystallization to occur at the temperature used, e.g., from 1 day to 28 days.

[035] Once the molecular sieve crystals have formed, the solid product is separated from the reaction mixture by standard mechanical separation techniques such as centrifugation or filtration. The crystals are water-washed and then dried to obtain the as-synthesized molecular sieve crystals. The drying step is typically performed at a temperature of less than 200°C.

[036] As a result of the crystallization process, the recovered crystalline molecular sieve product contains within its pore structure at least a portion of the structure directing agent used in the synthesis.

[037] The structure directing agent is typically at least partially removed from the molecular sieve by calcination before use. Calcination consists essentially of heating the molecular sieve comprising the structure directing agent at a temperature of from 200°C to 800°C in the presence of an oxygen-containing gas, optionally in the presence of steam. The structure directing agent can also be removed by photolysis techniques as described in U.S. Patent No. 6,960,327.

[038] To the extent desired and depending on the composition of the molecular sieve, any cations in the as-synthesized or calcined molecular sieve can be replaced in accordance with techniques well known in the art by ion exchange with other cations. Preferred replacing cations include metal ions, hydrogen ions, hydrogen precursor, e.g., ammonium ions and mixtures thereof. Particularly preferred cations are those which tailor the catalytic activity for certain organic conversion reactions. These include hydrogen, rare earth metals and metals of Groups 2 to 15 of the Periodic Table of the Elements. As used herein, the term "as-synthesized" refers to the molecular sieve in its form after crystallization, prior to removal of the SDA cation.

[039] The molecular sieve disclosed herein can be formulated with into a catalyst composition by combination with other materials, such as binders and/or matrix materials, which provide additional hardness or catalytic activity to the finished catalyst. When blended with such components, the relative proportions of the SSZ-105 molecular sieve and matrix may vary widely with the SSZ-105 content ranging from 1 to 99 wt. % (e.g., from 10 to 90 wt. % or from 20 to 80 wt. %) of the total catalyst.

Characterization of the Molecular Sieve

[040] Molecular sieve SSZ-105 is an intergrowth of the ERI and LEV crystal structures. Physical mixtures of the two phases ERI and LEV prepared by mixing samples of two pure materials are not defined as molecular sieve SSZ-105.

[041] In its as-synthesized and anhydrous form, molecular sieve SSZ-105 has a chemical composition, in terms of mole ratios, as described in Table 2:

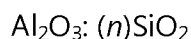
TABLE 2

	Broad	Exemplary
$\text{SiO}_2/\text{Al}_2\text{O}_3$	5 to 50	10 to 25
Q/SiO_2	0.02 to 0.20	0.05 to 0.20
M/SiO_2	0.01 to 0.20	0.02 to 0.15

wherein compositional variables Q and M are as described herein above.

[042] It should be noted that the as-synthesized form of the molecular sieve disclosed herein may have molar ratios different from the molar ratios of reactants of the reaction mixture used to prepare the as-synthesized form. This result may occur due to incomplete incorporation of 100% of the reactants of the reaction mixture into the crystals formed (from the reaction mixture).

[043] In its calcined form, molecular sieve SSZ-105 has chemical composition comprising the following molar relationship:



wherein n has a value of from 5 to 50 (e.g., from 5 to 25 or from 10 to 25).

[044] In one embodiment, the intergrown crystalline molecular sieve disclosed herein can have from 1% to 99% (e.g., from 5% to 95%, from 10% to 90%, from 20% to 80%, from 30% to 70%, from 40% to 60%) of the ERI crystal structure. Similarly, the intergrown molecular sieve disclosed herein can have from 1% to 99% (e.g., from 5% to 95%, from 10% to 90%, from 20% to 80%, from 30% to 70%, or from 40% to 60%) of the LEV crystal structure. The relative proportions of each of the phases can be analyzed by X-ray diffraction and, in particular, by comparing the observed patterns with calculated patterns generated using algorithms to simulate the effects of stacking disorder. DIFFaX is a computer program based on a mathematical model for calculating intensities from faults (see M.M.J. Treacy *et al.*, *Proc. R. Soc. Lond. A* 1991, 433, 499-520). DIFFaX is the simulation program selected by and available from the International Zeolite Association to simulate the powder XRD patterns for randomly intergrown phases (see "*Collection of Simulated XRD Powder Patterns for Zeolites*," Fifth Revised Edition, Elsevier, 2007).

[045] The powder X-ray diffraction patterns presented herein were collected by standard techniques. The radiation was CuK_α radiation. The peak heights and the positions, as a function of 2θ where θ is the Bragg angle, were read from the relative

intensities of the peaks (adjusting for background), and d , the interplanar spacing corresponding to the recorded lines, can be calculated.

[046] Minor variations in the diffraction pattern can result from variations in the mole ratios of the framework species of the particular sample due to changes in lattice constants. In addition, sufficiently small crystals will affect the shape and intensity of peaks, leading to significant peak broadening. Minor variations in the diffraction pattern can also result from variations in the organic compound used in the preparation. Calcination can also cause minor shifts in the XRD pattern. Notwithstanding these minor perturbations, the basic crystal lattice structure remains unchanged.

EXAMPLES

[047] The following illustrative examples are intended to be non-limiting.

EXAMPLE 1

[048] 0.70 g of 45% KOH solution, 1.21 g of deionized water, 1.00 g of CBV760 Y-zeolite powder (Zeolyst International, $\text{SiO}_2/\text{Al}_2\text{O}_3$ mole ratio = 60), and 4.48 g of 19% *N,N'*-dimethyl-1,4-diazabicyclo[2.2.2]octane dihydroxide solution were mixed together in a Teflon liner. The resulting gel was stirred until it became homogeneous. The liner was then capped and placed within a Parr steel autoclave reactor. The autoclave was then placed in an oven and the heated at 135°C for 3 days. The solid products were recovered by centrifugation, washed with deionized water and dried at 95°C.

[049] The resulting product had a $\text{SiO}_2/\text{Al}_2\text{O}_3$ mole ratio of 19.8, as determined by ICP elemental analysis.

[050] The resulting product was analyzed by powder XRD and SEM. The powder XRD pattern is shown in FIG. 1 and indicates that the product is pure SSZ-105 molecular sieve. The SEM image is shown in FIG. 2 and indicates a uniform field of crystals.

[051] A comparison between the experimental powder XRD pattern collected from the calcined product and DIFFaX simulated powder patterns with various ERI/LEV intergrowth ratios is shown in FIG. 3. DIFFaX calculation indicates that the product is an intergrowth material with approximately 40-50% of ERI stacking sequence and 60-50% of LEV stacking sequence.

EXAMPLE 2

[052] 0.60 g of 45% KOH solution, 0.13 g of 50% NaOH solution, 1.81 g of deionized water, 1.00 g of CBV760 Y-zeolite powder (Zeolyst International, $\text{SiO}_2/\text{Al}_2\text{O}_3$ mole ratio = 60), and 3.73 g of 19% *N,N'*-dimethyl-1,4-diazabicyclo[2.2.2]octane dihydroxide solution were mixed together in a Teflon liner. The resulting gel was stirred until it became homogeneous. The liner was then capped and placed within a Parr steel autoclave reactor. The autoclave was then placed in an oven and the heated at 135°C for 3 days. The solid products were recovered by centrifugation, washed with deionized water and dried at 95°C.

[053] The resulting product had a $\text{SiO}_2/\text{Al}_2\text{O}_3$ mole ratio of 13.6, as determined by ICP elemental analysis.

[054] The resulting product was identified by powder XRD as pure SSZ-105 molecular sieve.

[055] A comparison between the experimental powder XRD pattern collected from the calcined product and DIFFaX simulated powder XRD patterns with various ERI/LEV intergrowth ratios is shown in FIG. 4. DIFFaX calculation indicates that the product is an intergrowth material with approximately 80-90% of ERI stacking sequence and 20-10% LEV stacking sequence.

EXAMPLE 3

[056] 0.70 g of 45% KOH solution, 2.32 g of deionized water, 1.00 g of CBV760 Y-zeolite powder (Zeolyst International, $\text{SiO}_2/\text{Al}_2\text{O}_3$ mole ratio = 60), and

2.92 g of 23.71% of *N*-methyl quinuclidinium hydroxide solution were mixed together in a Teflon liner. The resulting gel was stirred until it became homogeneous. The liner was then capped and placed within a Parr steel autoclave reactor. The autoclave was then placed in an oven and the heated at 135°C for 4 days. The solid products were recovered by centrifugation, washed with deionized water and dried at 95°C.

[057] The resulting product had a SiO₂/Al₂O₃ mole ratio of 14.9, as determined by ICP elemental analysis.

[058] The resulting product was identified by powder XRD as pure SSZ-105 molecular sieve.

[059] A comparison between the experimental powder XRD pattern collected from the calcined product and DIFFaX simulated powder XRD patterns with various ERI/LEV intergrowth ratios is shown in FIG. 5. DIFFaX calculation indicates that the product is an intergrowth material with approximately 70-80% of ERI stacking sequence and 30-20% LEV stacking sequence.

EXAMPLE 4

[060] 0.70 g of 45% KOH solution, 6.09 g of deionized water, 1.00 g of CBV760 Y-zeolite powder (Zeolyst International, SiO₂/Al₂O₃ mole ratio = 60), and 2.92 g of 23.71% *N*-methyl quinuclidinium hydroxide solution were mixed together in a Teflon liner. The resulting gel was stirred until it became homogeneous. The liner was then capped and placed within a Parr steel autoclave reactor. The autoclave was then placed in an oven and the heated at 150°C for 4 days. The solid products were recovered by centrifugation, washed with deionized water and dried at 95°C.

[061] The resulting product had a SiO₂/Al₂O₃ mole ratio of 17.2, as determined by ICP elemental analysis.

[062] The resulting product was analyzed by powder XRD and identified as pure SSZ-105 molecular sieve.

[063] A comparison between the experimental powder XRD pattern collected from the calcined product and DIFFaX simulated powder XRD patterns with various ERI/LEV intergrowth ratios is shown in FIG. 6. DIFFaX calculation indicates that the product is an intergrowth material with approximately 50-60% of ERI stacking sequence and 50-40% LEV stacking sequence.

EXAMPLE 5

[064] 0.50 g of 45% KOH solution, 2.64 g of deionized water, 1.00 g of CBV760 Y-zeolite powder (Zeolyst International, $\text{SiO}_2/\text{Al}_2\text{O}_3$ mole ratio = 60), and 3.41 g of 23.71% *N*-methyl quinuclidinium hydroxide solution were mixed together in a Teflon liner. The resulting gel was stirred until it became homogeneous. The liner was then capped and placed within a Parr steel autoclave reactor. The autoclave was then placed in an oven and the heated at 135°C for 4 days. The solid products were recovered by centrifugation, washed with deionized water and dried at 95°C.

[065] The resulting product had a $\text{SiO}_2/\text{Al}_2\text{O}_3$ mole ratio of 20.1, as determined by ICP elemental analysis.

[066] The resulting product was analyzed by powder XRD and indicated that the product was pure SSZ-105 molecular sieve.

[067] A comparison between the experimental powder XRD pattern collected from the calcined product and DIFFaX simulated powder XRD patterns with various ERI/LEV intergrowth ratios is shown in FIG. 7. DIFFaX calculation indicates that the product is an intergrowth material with approximately 40-50% of ERI stacking sequence and 60-50% LEV stacking sequence.

EXAMPLE 6

[068] 0.50 g of 45% KOH solution, 5.83 g of deionized water, 1.00 g of CBV760 Y-zeolite powder (Zeolyst International, $\text{SiO}_2/\text{Al}_2\text{O}_3$ mole ratio = 60), and 3.41 g of 23.71% *N*-methyl quinuclidinium hydroxide solution were mixed together in a

Teflon liner. The resulting gel was stirred until it became homogeneous. The liner was then capped and placed within a Parr steel autoclave reactor. The autoclave was then placed in an oven and the heated at 150°C for 4 days. The solid products were recovered by centrifugation, washed with deionized water and dried at 95°C.

[069] The resulting product had a SiO₂/Al₂O₃ mole ratio of 21.4, as determined by ICP elemental analysis.

[070] The resulting product was analyzed by powder XRD and indicated that the product was pure SSZ-105 molecular sieve.

[071] A comparison between the experimental powder XRD pattern collected from the calcined product and DIFFaX simulated powder XRD patterns with various ERI/LEV intergrowth ratios is shown in FIG. 8. DIFFaX calculation indicates that the product is an intergrowth material with approximately 20-30% of ERI stacking sequence and 80-70% LEV stacking sequence.

EXAMPLE 7

Calcination of SSZ-105

[072] The as-synthesized molecular sieve products were calcined inside a muffle furnace under a flow of air heated to 540°C at a rate of 1°C/minute and held at 540°C for 5 hours, cooled and then analyzed by powder XRD.

[073] FIG. 3, FIG. 4, FIG. 5, FIG. 6, FIG. 7 and FIG. 8 show the powder XRD patterns of calcined SSZ-105 molecular sieve products prepared in Example 1, Example 2, Example 3, Example 4, Example 5 and Example 6, respectively, and indicate that the materials remain stable after calcination to remove the organic structure directing agent.

EXAMPLE 8

Micropore Volume Analysis

[074] The calcined material from Example 1 was treated with 10 mL (per g of molecular sieve) of a 1N ammonium nitrate solution at 90°C for 2 hours. The solution was cooled, decanted off and same process repeated.

[075] The ammonium-exchanged molecular sieve product (NH₄-SSZ-105) was subjected to a micropore volume analysis using N₂ as adsorbate and via the BET method. The molecular sieve exhibited a micropore volume of 0.20 cm³/g and indicates that SSZ-105 has microporous character.

[076] As used herein, the term "comprising" means including elements or steps that are identified following that term, but any such elements or steps are not exhaustive, and an embodiment can include other elements or steps.

[077] Unless otherwise specified, the recitation of a genus of elements, materials or other components, from which an individual component or mixture of components can be selected, is intended to include all possible sub-generic combinations of the listed components and mixtures thereof.

[078] All documents cited in this application are herein incorporated by reference in their entirety to the extent such disclosure is not inconsistent with this text.

CLAIMS

1. A method for preparing an aluminosilicate molecular sieve material comprising at least one intergrown phase comprising an ERI framework type molecular sieve and an LEV framework type molecular sieve, the method comprising:

(a) preparing a reaction mixture containing:

(1) at least one source of silicon oxide;

(2) at least one source of aluminum oxide;

(3) at least one source of a Group 1 metal (M), wherein M is selected from the group consisting of potassium and combinations of sodium and potassium;

(4) hydroxide ions;

(5) a structure directing agent (Q) selected from the group consisting of *N*-methyl quinuclidinium cations, *N,N'*-dimethyl-1,4-diazabicyclo[2.2.2]octane dications, and combinations thereof; and

(6) water; and

(b) subjecting the reaction mixture to crystallization conditions sufficient to form crystals of the molecular sieve material.

2. The method of claim 1, wherein the molecular sieve material is prepared from a reaction mixture comprising, in terms of mole ratios, the following:

$\text{SiO}_2/\text{Al}_2\text{O}_3$	10 to 100
M/SiO_2	0.05 to 1.00
Q/SiO_2	0.05 to 0.60
OH/SiO_2	0.10 to 1.00
$\text{H}_2\text{O}/\text{SiO}_2$	10 to 100

3. The method of claim 1, wherein the molecular sieve material is prepared from a reaction mixture comprising, in terms of mole ratios, the following:

$\text{SiO}_2/\text{Al}_2\text{O}_3$	15 to 80
M/SiO_2	0.15 to 0.45
Q/SiO_2	0.15 to 0.40
OH/SiO_2	0.40 to 0.95
$\text{H}_2\text{O}/\text{SiO}_2$	15 to 40

4. The method of claim 1, wherein the crystallization conditions include a temperature of from 125°C to 200°C.

5. The method of claim 1, wherein the ERI framework type molecular sieve is present in the at least one intergrown phase in a proportion to the LEV framework type molecular sieve of from 5% to 95%.

6. The method of claim 1, wherein the molecular sieve material has, in its as-synthesized and anhydrous form, a composition, in terms of mole ratios, comprising the following:

$\text{SiO}_2/\text{Al}_2\text{O}_3$	5 to 50
Q/SiO_2	0.02 to 0.20
M/SiO_2	0.01 to 0.20

7. The method of claim 1, wherein the molecular sieve material has, in its as-synthesized and anhydrous form, a composition, in terms of mole ratios, comprising the following:

$\text{SiO}_2/\text{Al}_2\text{O}_3$	10 to 25
Q/SiO_2	0.05 to 0.20
M/SiO_2	0.02 to 0.15

8. An aluminosilicate molecular sieve material comprising at least one intergrown phase comprising an ERI framework type molecular sieve and an LEV framework type molecular sieve, wherein the molecular sieve material has, in its as-synthesized and anhydrous form, a composition, in terms of mole ratios, comprising the following:

$\text{SiO}_2/\text{Al}_2\text{O}_3$	5 to 50
Q/SiO_2	0.02 to 0.20
M/SiO_2	0.01 to 0.20

wherein Q is selected from the group consisting of *N*-methyl quinuclidinium cations, *N,N'*-dimethyl-1,4-diazabicyclo[2.2.2]octane dications, and combinations thereof; and M is a Group 1 metal selected from the group consisting of potassium and combinations of sodium and potassium.

9. The aluminosilicate molecular sieve material of claim 8, wherein the molecular sieve material has, in its as-synthesized and anhydrous form, a composition, in terms of mole ratios, comprising the following:

$\text{SiO}_2/\text{Al}_2\text{O}_3$	10 to 25
Q/SiO_2	0.05 to 0.20
M/SiO_2	0.02 to 0.15

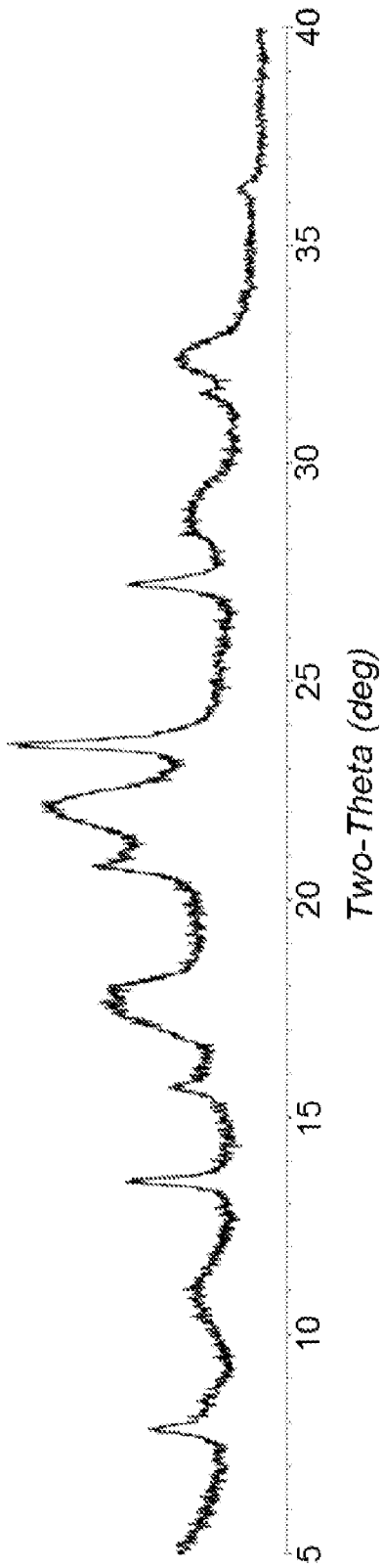


FIG. 1

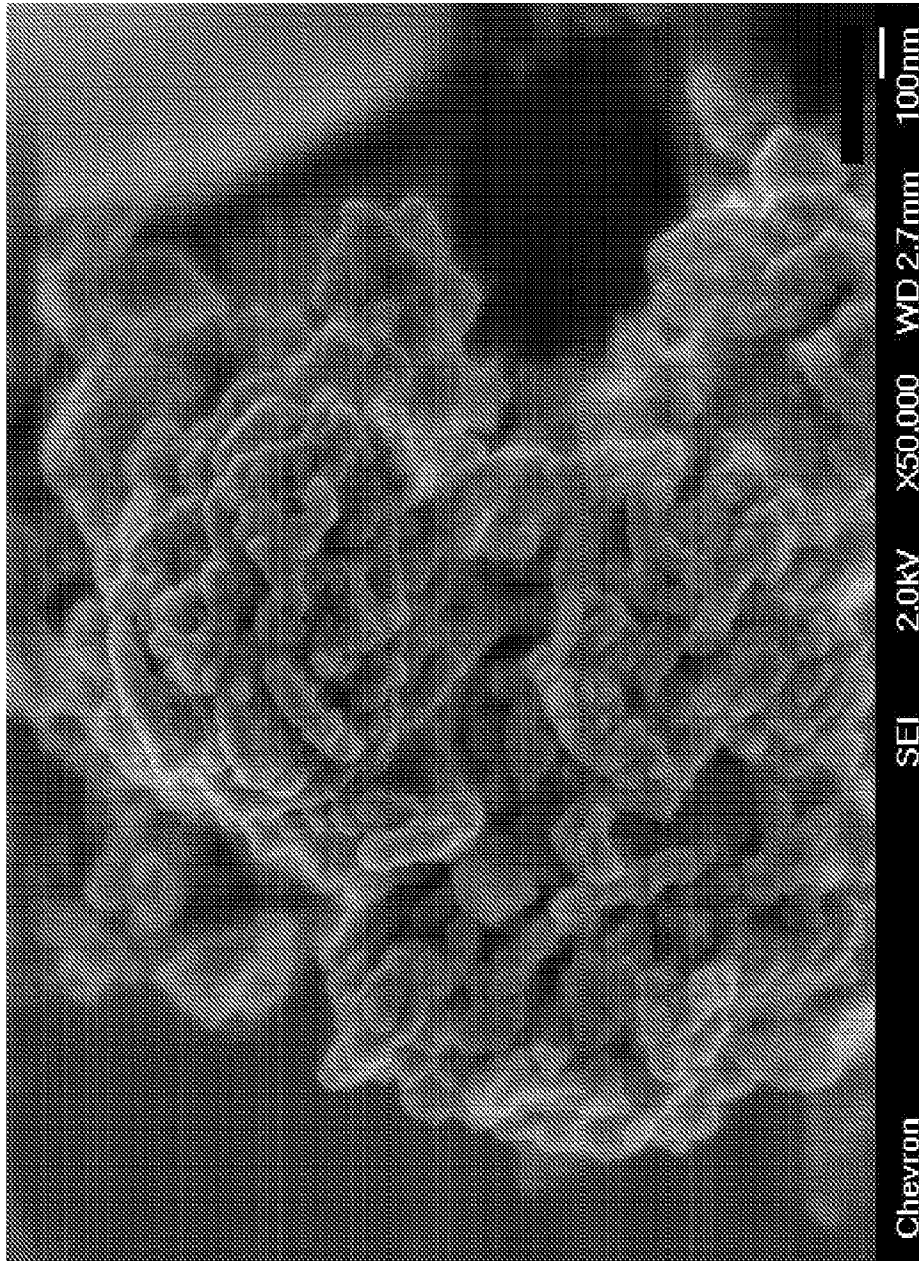


FIG. 2

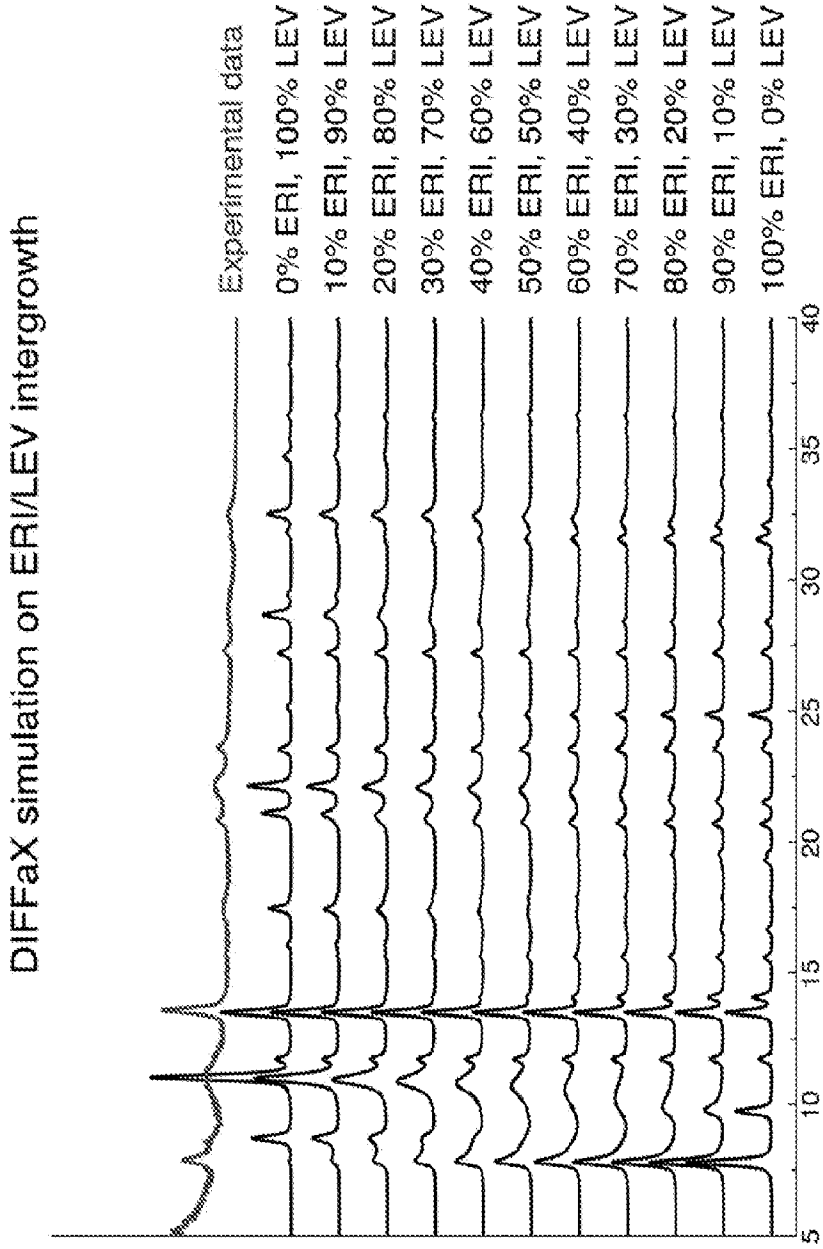


FIG. 3

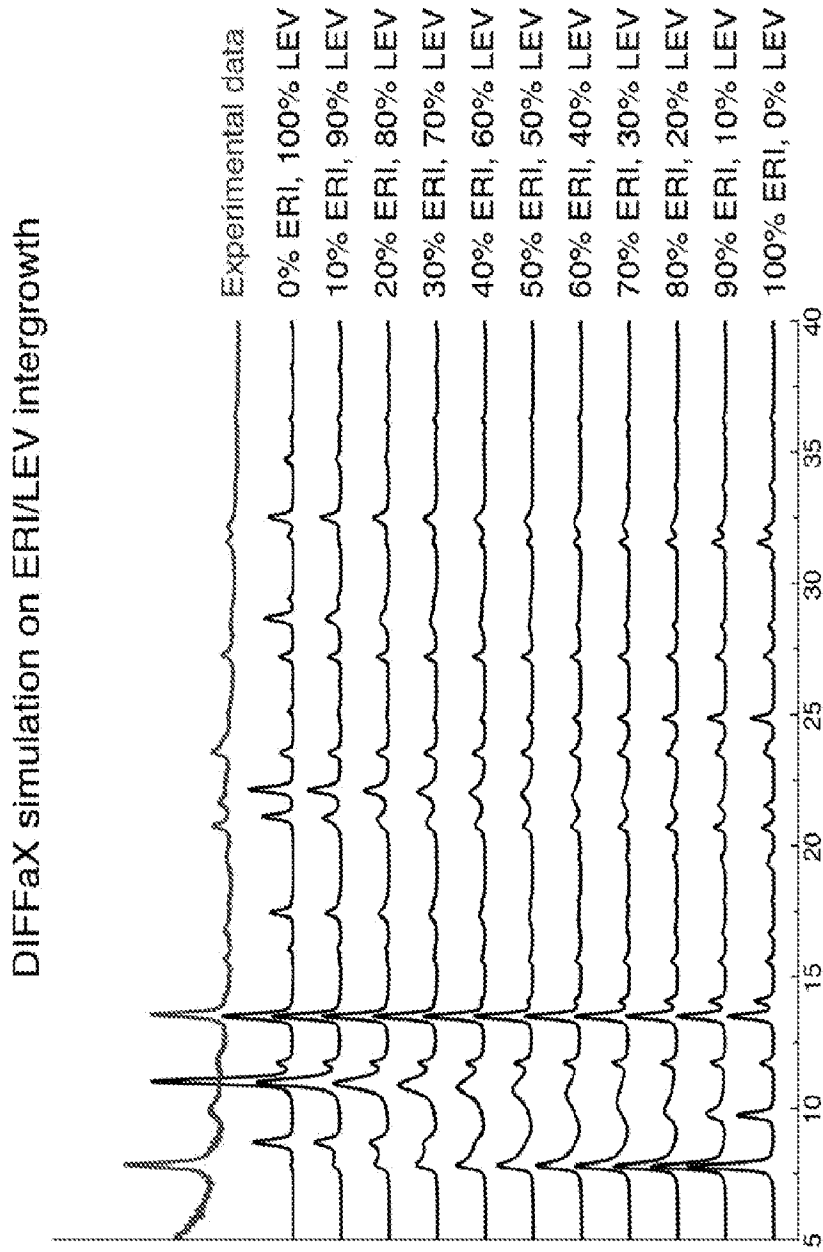


FIG. 4

DIFFaX simulation on ERI/LEV intergrowth

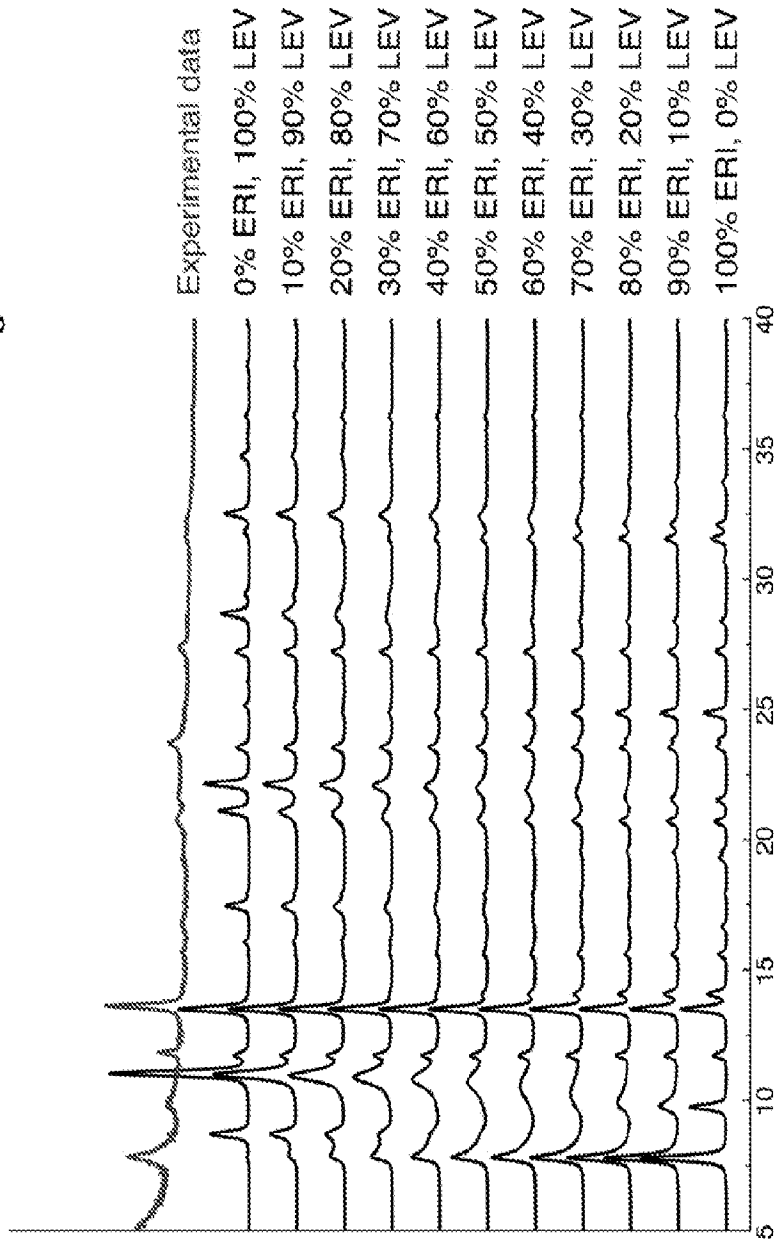


FIG. 5

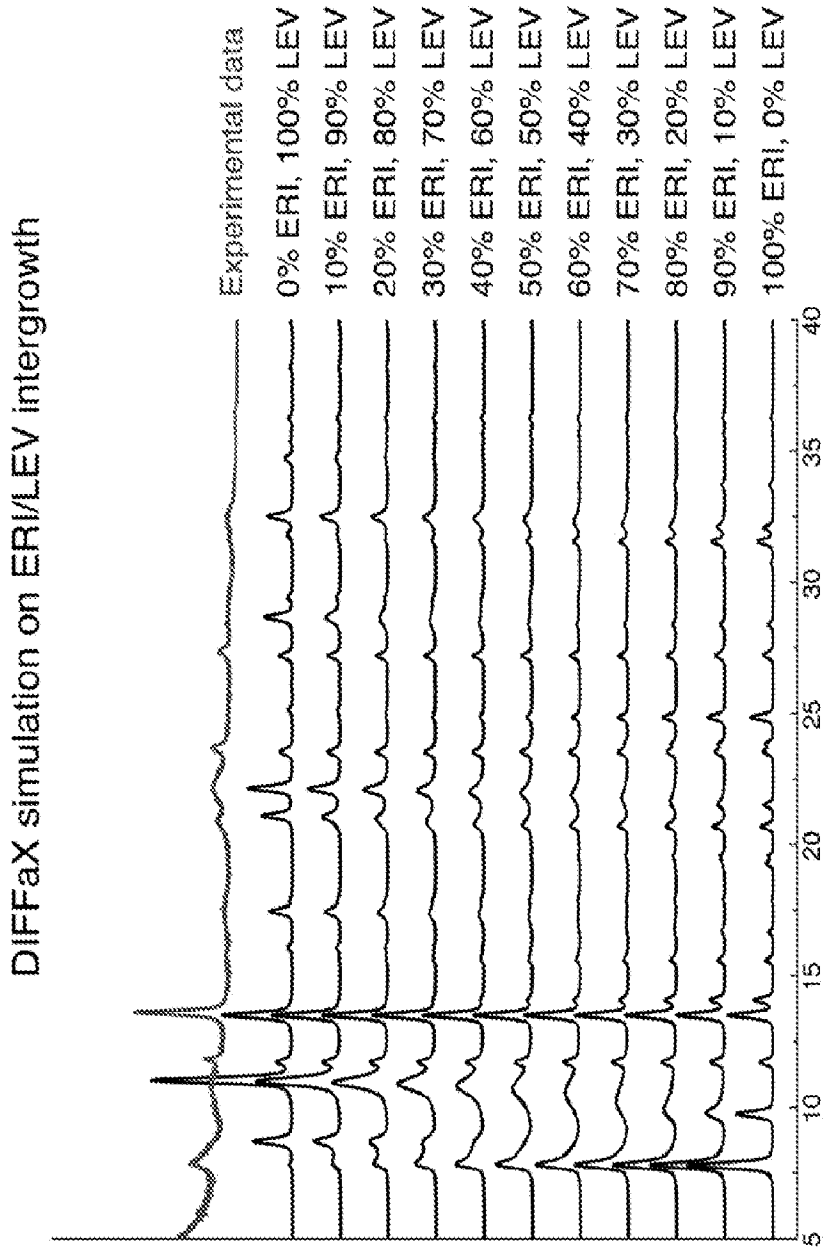


FIG. 6

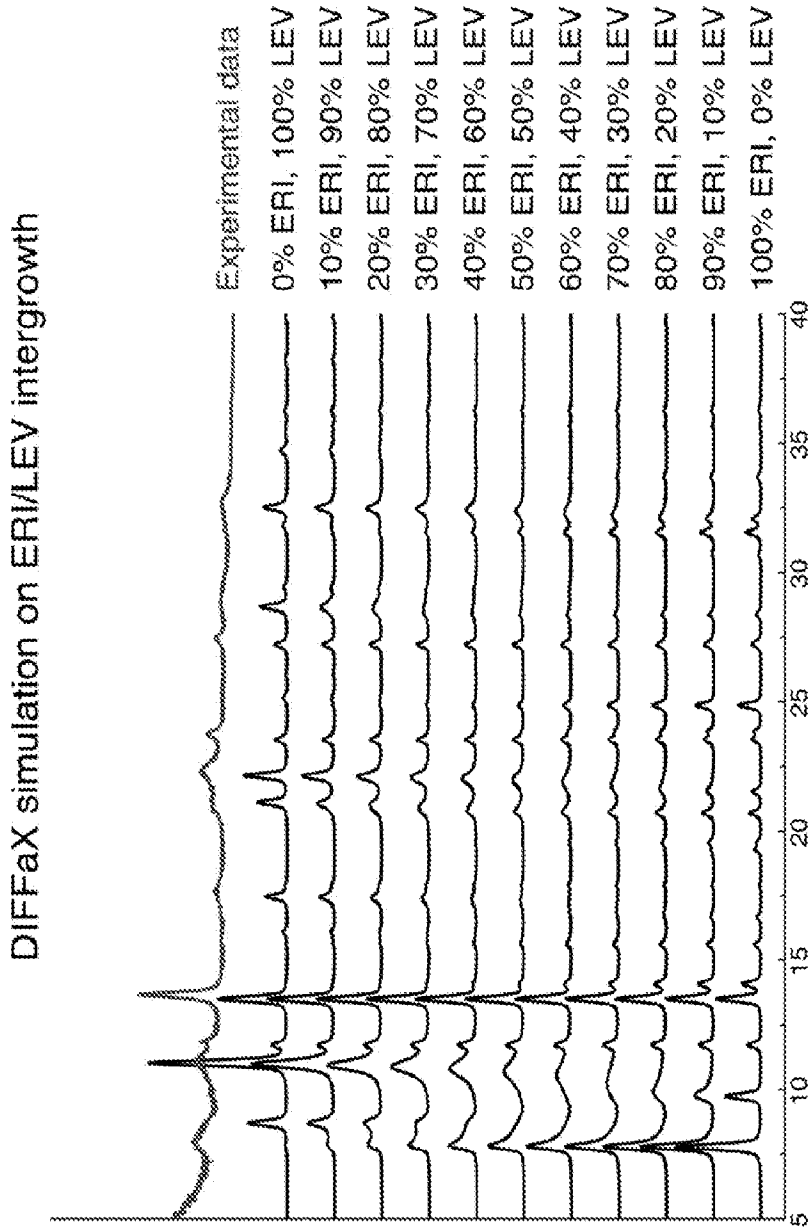


FIG. 7

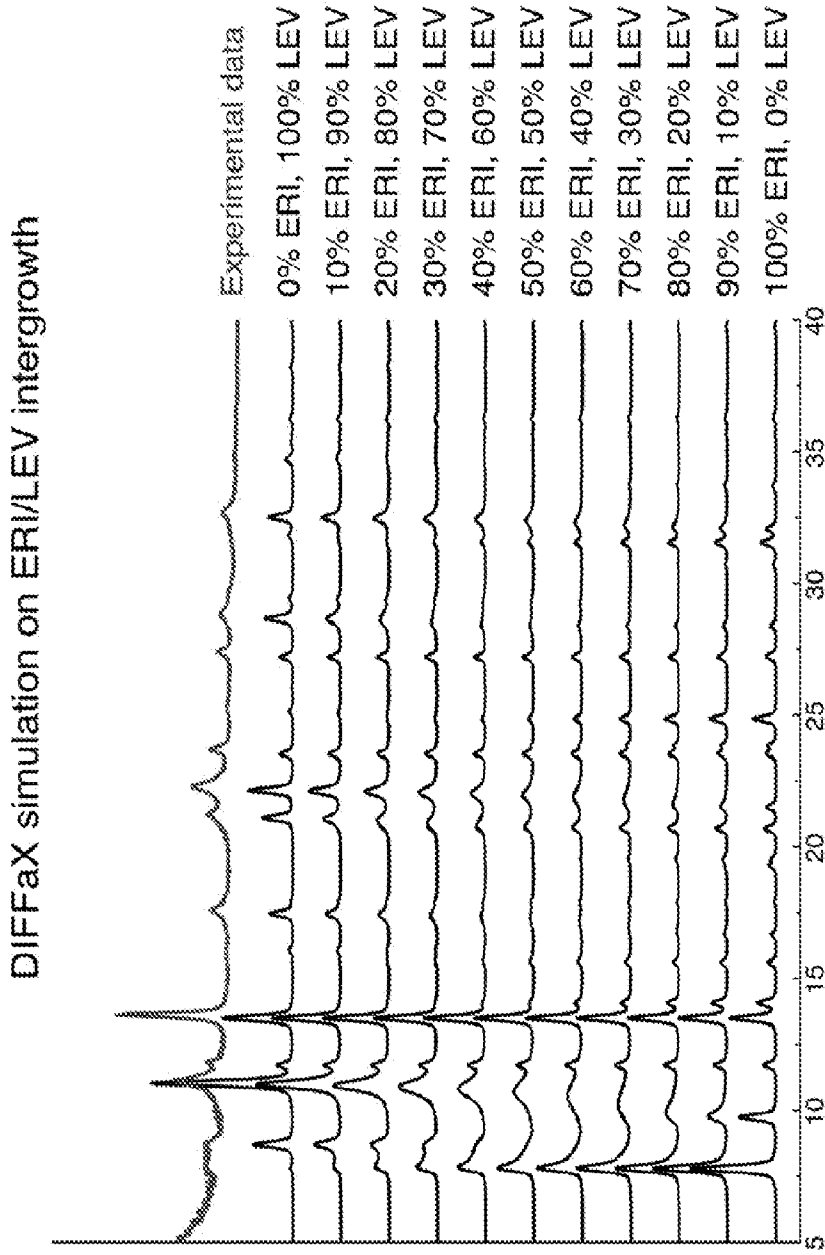


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/056784

A. CLASSIFICATION OF SUBJECT MATTER
INV. C01B39/02 C01B39/30 C01B39/48
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
C01B
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, COMPENDEX, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 040 016 A1 (ICI PLC [GB]) 18 November 1981 (1981-11-18) example 7 page 8, line 18 - page 10, line 26 the whole document	1-9
A	KUBOTA Y ET AL: "synthesis of a new molecular sieve using DABCO-based structure-directing agent", CATALYSIS TODAY, ELSEVIER, AMSTERDAM, NL, vol. 74, 1 January 2002 (2002-01-01), pages 271-279, XP002627014, ISSN: 0920-5861 2. Experimental; page 272; figure 1; table 1 the whole document	1-9
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Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search 10 January 2017	Date of mailing of the international search report 17/01/2017
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Follens, Lana

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/056784

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>AYAKO YASHIKI ET AL: "Hydrothermal conversion of FAU zeolite into LEV zeolite in the presence of non-calcined seed crystals", JOURNAL OF CRYSTAL GROWTH, vol. 325, no. 1, 7 May 2011 (2011-05-07), pages 96-100, XP055071366, ISSN: 0022-0248, DOI: 10.1016/j.jcrysgr.2011.04.040 2.1. Synthesis of LEV zeolite; page 97; table 1 the whole document</p> <p style="text-align: center;">-----</p>	1-9

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2016/056784

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