often involve the use of organic structure-directing agents (many of which are not commercially available).

SUMMARY

[0006a] In a first aspect, the present disclosure refers to a method for preparing finned zeolite crystals, comprising:

preparing a secondary growth solution for epitaxial growth of finned protrusions from zeolite seed crystals, wherein the secondary growth solution comprises one or more framework source precursors, one or more structure-directing agents, and a hydroxide source, wherein the one or more framework source precursors comprise a silica source and an alumina source;

adding the zeolite seed crystals in an amount of about 5 to about 30 weight percent of the secondary growth solution to produce a seeded growth solution;

heating the seeded growth solution to a temperature of about 100°C to about 170°C for about 6 to about 48 hours, to produce epitaxially grown fins on the zeolite seed crystals;

quenching the seeded growth solution to room temperature to produce a final growth solution; and

isolating finned zeolite crystals from the final growth solution, wherein the finned zeolite crystals comprise a zeolite seed crystal portion and a plurality of epitaxially grown fins extending from outer surfaces of the zeolite seed crystal portion, wherein the zeolite seed crystal portion comprises the zeolite seed crystals, wherein the zeolite seed crystal portion has a characteristic size of β, wherein the epitaxially grown fins have a characteristic size of α, wherein β is greater than α, and wherein α is less than about 50 nm.

[0006b] In another aspect, the present disclosure refers to the finned zeolite crystals prepared by the method as disclosed herein.

[0006c] In a further aspect, the present disclosure refers to finned zeolite crystals, comprising:

a zeolite seed crystal portion, wherein the seed portion comprises a single crystallographic registry, and wherein the seed portion comprises a network of pores; and

a plurality of epitaxially grown fins extending from outer surfaces of the zeolite seed crystal portion, wherein the epitaxially grown fins comprise a single crystallographic registry that is identical to the single crystallographic registry of the zeolite seed crystal portion, and wherein the epitaxially grown fins comprise a network of pores that is continuous with the network of pores of the zeolite seed crystal portion.

[0007] The present disclosure relates generally to a post-synthetic route to make a new class of microporous materials with reduced diffusion limitations, referred to as "finned" zeolite crystals. Inspired by conventional fins which enhance interfacial heat transfer, finned zeolite crystals are comprised of a seed (with a characteristic size of β) and epitaxially grown protrusions (with a characteristic size of α, where $\alpha << \beta$). The growth of protrusions is accomplished by a seeding method where zeolite crystals are placed in a secondary growth solution that results in the formation of a roughened interface on the surfaces of the seeds owing to a population of fins. The growth solution and conditions of secondary synthesis were designed in such a way to minimize homogeneous nucleation of new crystals and preferentially grow fins on the crystal seeds. The conditions of secondary growth can be adjusted to vary the density (or coverage) and size of fins. This process is generalizable to a wide range of zeolite framework types. The synthesis of finned zeolites has been demonstrated on three different crystal structures: ZSM-5 (MFI), ZSM-11 (MEL), and ferrierite (FER). Both MEL and MFI frameworks are comprised of 3-dimensional intersecting medium-sized channels, whereas the FER framework is comprised of 2-dimensional intersecting small- and medium-sized channels.

[0008] The method disclosed herein relies on the post-synthesis modification of existing (seed) crystals. Fins can be generated via a one-pot process; however, the exact set of synthesis conditions is unpredictable, and is thus less generalizable to a broad set of crystal structures. The seeded growth approach is one that more reproducibly (and predictably) leads to finned materials. One of the difficulties of preparing finned zeolites is identifying growth mixtures that promote the nucleation and growth of protrusions on the surfaces of seed crystals. Systematic experiments have

identified conditions that are optimal for finned zeolite formations. The conditions that can be manipulated to tailor finned zeolites include (but are not limited to) temperature, the introduction of organics, synthesis time, supersaturation (i.e. silica and/or alumina concentrations), the sources of silica and alumina, and alkalinity. For example, synthesis at high temperature may promote homogeneous nucleation of crystals that are isolated from the seed crystals, thus generating a bimodal distribution of crystal sizes (or aggregates of crystals). Conversely, synthesis at low temperature may be insufficient to nucleate fins on the surfaces of zeolite seed crystals.

WHAT IS CLAIMED IS:

1. A method for preparing finned zeolite crystals, comprising:

preparing a secondary growth solution for epitaxial growth of finned protrusions from zeolite seed crystals, wherein the secondary growth solution comprises one or more framework source precursors, one or more structure-directing agents, and a hydroxide source, wherein the one or more framework source precursors comprise a silica source and an alumina source;

adding the zeolite seed crystals in an amount of about 5 to about 30 weight percent of the secondary growth solution to produce a seeded growth solution;

heating the seeded growth solution to a temperature of about 100°C to about 170°C for about 6 to about 48 hours, to produce epitaxially grown fins on the zeolite seed crystals;

quenching the seeded growth solution to room temperature to produce a final growth solution; and

isolating finned zeolite crystals from the final growth solution, wherein the finned zeolite crystals comprise a zeolite seed crystal portion and a plurality of epitaxially grown fins extending from outer surfaces of the zeolite seed crystal portion, wherein the zeolite seed crystal portion comprises the zeolite seed crystals, wherein the zeolite seed crystal portion has a characteristic size of β, wherein the epitaxially grown fins have a characteristic size of α, wherein β is greater than α, and wherein α is less than about 50 nm.

~~2. The method of claim 1, wherein the one or more framework source precursors comprise one or both of a silica source and an alumina source.~~

~~3.~~2. The method of claim 1, wherein the one or more framework source precursors comprise sodium silicate, tetraethylorthosilicate, colloidal silicate, fumed silica, SiO_2, aluminum sulfate, aluminum hydroxide, Al_2O_3, or combinations thereof.

~~4.~~3. The method of claim 1, wherein the structure-directing agents are inorganic, organic, or a combination thereof.

~~5.~~4. The method of claim 1, wherein the structure-directing agents are selected from pyrrolidine, tetrapropylammonium hydroxide, 1,8-diaminooctane, cyclohexylamine and tetrabutylammonium hydroxide.

~~6.~~5. The method of claim 1, wherein the hydroxide source is Na_2O or K_2O.

~~7.~~6. The method of claim 1, wherein the secondary growth solution has a molar composition ratio of a first framework source precursor to a second framework source precursor of about 40:1 to about 120:1.

~~8.~~7. The method of claim ~~6~~7, wherein the first framework source precursor is SiO_2 and the second framework source precursor is Al_2O_3.

~~9.~~8. The method of claim 1, wherein the secondary growth solution has a molar composition ratio of a framework source precursor to a structure directing agent of about 2:1 to about 15:1.

~~10.~~9. The method of claim 1, wherein the secondary growth solution has a molar composition ratio of a framework source precursor to the hydroxide source of about 8:1 to about 65:1.

~~11.~~10. The method of claim 1, wherein the finned zeolite crystals are MEL type, MFI type, or FER type.

~~12.~~11. The finned zeolite crystals prepared by the method of claim 1.

~~13.~~12. Finned zeolite crystals, comprising:

a zeolite seed crystal portion, wherein the seed portion comprises a single crystallographic registry, and wherein the seed portion comprises a network of pores; and

a plurality of epitaxially grown fins extending from outer surfaces of the zeolite seed crystal portion, wherein the epitaxially grown fins comprise a single crystallographic registry that is identical to the single crystallographic registry of the zeolite seed crystal portion, and wherein the epitaxially

grown fins comprise a network of pores that is continuous with the network of pores of the zeolite seed crystal portion.

~~14.~~13. The finned zeolite crystals of claim 12~~13~~, wherein the zeolite seed crystal portion has a characteristic size of β, wherein the epitaxially grown fins have a characteristic size of α, and wherein β is greater than α.

~~15.~~14. The finned zeolite crystals of claim 13~~14~~, wherein α is less than about 50 nm.

~~16.~~15. The finned zeolite crystals of claim 13~~14~~, wherein adjacent epitaxially grown fins are separate by a pitch, and wherein an average pitch between adjacent expitaxially grown fins is about 20 nm to about 100 nm.

~~17.~~16. The finned zeolite crystals of claim 12~~13~~, wherein the finned zeolite crystals are M EL type, MFI type, or FER type.