A combination of steam treatment and acid treatment is described in WO 2009/016153 A2. According to this document, phosphorus-modified molecular sieves having a low Si/Al ratio are subjected to a steam treatment at high temperatures before a leaching step with an acidic solution is carried out to remove Al from the zeolitic framework structure.

Both the steam treatment and the acid treatment have a significant influence on the properties of the zeolitic material. By subjecting a zeolitic material comprising both tetravalent and trivalent structural components YO_2 and X_2O_3, respectively, to a steam and/or an acid treatment, the $YO_2 : X_2O_3$ molar ratio is increased. However, it was found that the crystallinity of the zeolitic material is decreased by the steam treatment and/or the acid treatment, and that the hydrophobicity of the zeolitic material decreases. Therefore, it was found that the steam treatment and the acid treatment both result in a partial transformation of the zeolitic material into an amorphous material. Further, by changing the hydrophobicity, the originally intended use of the zeolitic material is often no longer possible. Therefore, although a desired $YO_2 : X_2O_3$ molar ratio can be achieved by the steam treatment or the acid treatment, the obtained zeolitic materials have major disadvantages which, among others, make them uninteresting for commercial use.

Therefore, it was an object of the embodiments disclosed herein to provide a process for the post-treatment of a zeolitic material which does not exhibit said disadvantages.

Further, it was an object of the embodiments disclosed herein to provide a post-treated zeolitic material with a high $YO_2 : X_2O_3$ molar ratio and simultaneously a high crystallinity. It was also an object of the embodiments disclosed herein to provide a post-treated zeolitic material having a high $YO_2 : X_2O_3$ molar ratio, a high cristallinity and at the same time a reduced concentration of internal defects such as silanol nests. In particular, it has been observed that the treatment of a zeolitic material for increasing the $YO_2 : X_2O_3$ molar ratio such as by acid treatment leads to the increased formation of silanol nests which are for example characterized by an adsorbtion band in the IR spectrum of the zeolitic material located in the range of from 3600 cm^{-1} to 3700 cm^{-1}. Within the meaning of the present disclosure, the term "silanol nests" preferably refers to hydrogen-bonded Si-OH groups of which the characteristic absorption in the IR spectra of e.g. silicalites is found in the range of 3200 to 3650 cm^{-1}, as described in Zecchina et al. in *J. Phys. Chem.* **1992**, *96*, pp. 4991-4997.

Surprisingly, it was found that a post-treatment process which involves subjecting a zeolitic material comprising YO_2 and X_2O_3 to at least one treatment with an aqueous solution having a pH of at most 5 and at least one treatment with a liquid aqueous system having a pH in the range of 5.5 to 8 at elevated temperatures of at least 75 °C avoids said disadvantages. In particular, it was further surprisingly found that although the X elements are partially removed from the zeolitic material during said post-treatment process, the

resulting zeolitic material, however, exhibits an increased crystallinity and even a reduced concentration of internal defects.

Therefore, the present disclosure relates to a process for the post-treatment of a zeolitic material, the process comprising

(i) providing a zeolitic material, wherein the framework structure of the zeolitic material comprises YO_2 and X_2O_3, wherein Y is a tetravalent element and X is a trivalent element;

(ii) subjecting the zeolitic material provided in (i) to a method comprising

(a) treating the zeolitic material with an aqueous solution having a pH of at most 5;

(b) treating the zeolitic material obtained from (a) with a liquid aqueous system having a pH in the range of 5.5 to 8 and a temperature of at least 75 °C;

wherein in (ii) and after (b), the zeolitic material is optionally subjected to at least one further treatment according to (a) and/or at least one further treatment according to (b), and wherein the pH of the aqueous solution according to (a) and the pH of the liquid aqueous system according to (b) is determined using a pH sensitive glass electrode.

Therefore, the process of the present disclosure can comprise two or more treatments according to (a) and/or two or more treatments according to (b). If the process comprises two or more treatments according to (a), the conditions in a given treatment (a) can be identical to or different from the conditions in another treatment (a). If the process comprises two or more treatments according to (b), the conditions in a given treatment (b) can be identical to or different from the conditions in another treatment (b).

In an aspect, there is provided a process for a post-treatment of a zeolitic material, the process comprising:

(i) providing the zeolitic material, wherein the zeolitic material has a framework structure comprising YO_2 and X_2O_3, wherein Y is a tetravalent element and X is a trivalent element, and wherein Y is selected from the group consisting of Si, Sn, Ti, Zr, Ge, and any combination thereof, and wherein X is selected from the group consisting of Al, B, In, Ga, Fe and any combination thereof;

(ii) subjecting the zeolitic material to a method comprising

(a) treating the zeolitic material with an acidic aqueous solution having a pH of at most 5, wherein the aqueous solution comprises at least one of an organic acid and an inorganic acid; and

(b) treating the zeolitic material obtained from (a) with a liquid aqueous system having a pH ranging from 5.5 to 8 and at a temperature of at least 75 °C, wherein the liquid aqueous system comprises at least 90 weight-% water,

wherein neither in (i) nor in (ii), the zeolitic material is subjected to water stream treatment;

wherein the pH of the aqueous solution according to (a) and the pH of the liquid aqueous system according to (b) is determined using a pH sensitive glass electrode.

In another aspect, there is provided a zeolitic material, having a framework structure which comprises YO_2 and X_2O_3, wherein Y is a tetravalent element and X is a trivalent element, wherein Y is selected from the group consisting of Si, Sn, Ti, Zr, Ge and any combination thereof, wherein X is selected from the group consisting of Al, B, In, Ga, Fe and any combination thereof, wherein the zeolitic material is characterized by a IR spectrum exhibiting a first absorption band with a maximum in a range of from 3730 cm^{-1} to 3750 cm^{-1} and a second absorption band with a maximum in a range of from 3600 cm^{-1} to 3700 cm^{-1}, wherein a ratio of a peak height of the second absorption band relative to a peak height of the first absorption band is in a range of from 0.1 to 0.9.

In another aspect, there is provided a zeolitic material obtained by the process as defined above.

According to the present invention, YO_2 and X_2O_3 comprised in the framework structure of the zeolitic materials provided in step (i) are contained in the framework structure as frameworking-forming elements, as opposed to non-framework elements which can be present in the pores and cavities formed by the framework structure and which can be typical for zeolitic materials in general.

As far as the chemical nature of Y and X is concerned, no specific restrictions exist. In particular, Y can be any conceivable tetravalent element or mixture of two or more tetravalent elements, and X can be any conceivable trivalent element or mixture of two or more trivalent elements. Preferred tetravalent elements according to the present invention include, but are not restricted to, Si, Sn, Ti, Zr, and Ge. Preferred trivalent elements according to the present invention include, but are not restricted to, Al, B, In, Ga and Fe. Preferably, Y is selected from the group consisting of Si, Sn, Ti, Zr, Ge and combinations of two or more thereof, Y preferably being Si, and X is selected from the group consisting of Al, B, In, Ga, Fe and combinations of two or more thereof, X preferably being Al.

Claims

1. A process for a post-treatment of a zeolitic material, the process comprising:
   (i) providing the zeolitic material, wherein the zeolitic material has a framework structure comprising YO_2 and X_2O_3, wherein Y is a tetravalent element and X is a trivalent element, and wherein Y is selected from the group consisting of Si, Sn, Ti, Zr, Ge, and any combination thereof, and wherein X is selected from the group consisting of Al, B, In, Ga, Fe and any combination thereof;
   (ii) subjecting the zeolitic material to a method comprising
      (a) treating the zeolitic material with an acidic aqueous solution having a pH of at most 5, wherein the aqueous solution comprises at least one of an organic acid and an inorganic acid; and
      (b) treating the zeolitic material obtained from (a) with a liquid aqueous system having a pH ranging from 5.5 to 8 and at a temperature of at least 75 °C, wherein the liquid aqueous system comprises at least 90 weight-% water,

   wherein neither in (i) nor in (ii), the zeolitic material is subjected to water stream treatment;

   wherein the pH of the aqueous solution according to (a) and the pH of the liquid aqueous system according to (b) is determined using a pH sensitive glass electrode.

2. The process of claim 1, wherein the method according to (ii) comprises:
   (a) treating the zeolitic material with the acidic aqueous solution having a pH of at most 5;
   (b) treating the zeolitic material obtained from (a) with a liquid aqueous system having a pH ranging from 5.5 to 8 and at a temperature of at least 75 °C; and
   (c) treating the zeolitic material obtained from (b) with the acidic aqueous solution having a pH of at most 5.

3. The process of claim 2, wherein after (a), the zeolitic material is subjected to a treatment with a liquid aqueous system having a pH ranging from 5.5 to 8 and at a temperature of less than 75 °C.

4. The process of claim 1, wherein in (a), the acidic aqueous solution comprises one or more of an organic acid selected from the group consisting of oxalic acid, acetic acid, citric acid, methane sulfonic acid, and any mixture thereof, and of an inorganic acid selected from the group consisting of phosphoric acid, sulphuric acid, hydrochloric acid, nitric acid, and any mixture thereof.

5. The process of claim 1, wherein in (a), the acidic aqueous solution has a pH ranging from 0 to 5.

6. The process of claim 1, wherein in (a), the zeolitic material is treated with the acidic aqueous solution at a temperature ranging from 20 °C to 100 °C.

7. The process of claim 1, wherein in (a), the zeolitic material is treated with the acidic aqueous solution for a period ranging from 10 min to 12 h.

8. The process of claim 1, wherein in (b), the zeolitic material is treated with the liquid aqueous system at a temperature ranging from 80 °C to 180 °C.

9. The process of claim 1, wherein in (b), the zeolitic material is treated with the liquid aqueous system for a period ranging from 0.5 h to 24 h.

10. The process of claim 1, wherein in (b), a weight ratio of the liquid aqueous system relative to the zeolitic material ranges from 20:1 to 2:1.

11. The process of claim 1, wherein in (b), the liquid aqueous system comprises at least 99 weight-% water.

12. The process of claim 1, wherein in (ii) and after (b), the zeolitic material is subjected to one or more of drying and calcination.

13. The process of claim 1, wherein Y is Si, and wherein X is Al.

14. The process of claim 1, wherein one or more of the acidic aqueous solution according to (a) and of the liquid aqueous system according to (b) comprise one or more of at least one salt of at least one organic acid and of at least one salt of at least one inorganic acid.

15. The process of claim 14, wherein the at least one salt is an ammonium salt and the zeolitic material provided in (i) is in a sodium form.

16. The process of claim 1, wherein (i) comprises an organotemplate-free synthetic method comprising

(1) preparing a mixture comprising seed crystals and at least one source for YO_2 and at least one source for X_2O_3, and

(2) crystallizing the zeolitic material from the mixture,

wherein the seed crystals comprise zeolitic material having the framework structure of the zeolitic material.

17. The process of claim 1, wherein the zeolitic material in (i) has a LEV, CHA, MFI, MWW, BEA framework structure.

18. The process of claim 1, wherein neither in (i) nor in (ii) nor after (ii), the zeolitic material is subjected to water steam treatment.

19. A zeolitic material, having a framework structure which comprises YO_2 and X_2O_3, wherein Y is a tetravalent element and X is a trivalent element, wherein Y is selected from the group consisting of Si, Sn, Ti, Zr, Ge and any combination thereof, wherein X is selected from the group consisting of Al, B, In, Ga, Fe and any combination thereof, wherein the zeolitic material is characterized by a IR spectrum exhibiting a first absorption band with a maximum in a range of from 3730 cm^{-1} to 3750 cm^{-1} and a second absorption band with a maximum in a range of from 3600 cm^{-1} to 3700 cm^{-1}, wherein a ratio of a peak height of the second absorption band relative to a peak height of the first absorption band is in a range of from 0.1 to 0.9.

20. The zeolitic material of claim 19, wherein the $YO_2 : X_2O_3$ molar ratio is in a range of from 20 : 1 to 60 : 1.

21. The zeolitic material of claim 19, wherein a water uptake of the zeolitic material is at most 20 weight-%.

22. The zeolitic material of claim 19, wherein the ratio of the peak height of the second absorption band relative to the peak height of the first absorption band is in a range of from 0.2 to 0.8.

23. The zeolitic material of claim 19, wherein Y is Si, and wherein X is Al.

24. The zeolitic material of claim 19, having a LEV, CHA, MFI, MWW, BEA framework structure.

25. The zeolitic material of claim 19, wherein Y is Si and X is Al, and the zeolitic material is dealuminated zeolite Beta.

26. A zeolitic material obtained by the process of claim 1