Claims

1. A modified Y-type molecular sieve, having a rare earth content of 4% to 11% by weight on the basis of rare earth oxide, a sodium content of no more than 0.5% by weight on the basis of sodium oxide, a zinc content of 0.5% to 5% by weight on the basis of zinc oxide, and a phosphorus content of 0.05% to 10% by weight on the basis of phosphorus pentoxide, based on the weight of the modified Y-type molecular sieve on a dry basis; a framework silica-alumina ratio of 7 to 14 calculated on the basis of SiO_2/Al_2O_3 molar ratio, a percentage of non-framework aluminum content to the total aluminum content of no more than 10%, and a percentage of the pore volume of secondary pores having a pore size of 2-100 nm to the total pore volume of 20% to 40%, a ratio of B acid to L acid in the strong acid content of the modified Y-type molecular sieve of 3.5-6.5, as determined by pyridine adsorption infrared spectroscopy at 350 °C.

2. The modified Y-type molecular sieve according to claim 1, wherein the modified Y-type molecular sieve has one or more of the following characteristics:

a total pore volume of the modified Y-type molecular sieve of 0.36 mL/g to 0.48 mL/g;

a lattice constant of the modified Y-type molecular sieve of 2.440 nm to 2.455 nm;

a percentage of non-framework aluminum content to the total aluminum content of the modified Y-type molecular sieve of 5% to 9.5%;

a percentage of the pore volume of secondary pores having a pore size of 2-100 nm to the total pore volume of the modified Y-type molecular sieve of 28% to 38%;

a lattice collapse temperature of the modified Y-type molecular sieve of not lower than 1060 °C;

a relative crystallinity of the modified Y-type molecular sieve of no less than 60%; and/or

a relative crystallinity retention of the modified Y-type molecular sieve of 38% or more after being aged at 800 °C under atmospheric pressure in a 100 vol% steam atmosphere for 17 hours.

3. The modified Y-type molecular sieve according to claim 1 or 2, wherein the modified Y-type molecular sieve has a rare earth content of 4.5% to 10% by weight, a sodium content of 0.05% to 0.3% by weight, a phosphorus content of 0.1% to 6% by weight, based on the weight of the modified Y-type molecular sieve on a dry basis; a lattice constant of 2.442 nm to 2.451 nm, and a framework silica-alumina ratio of 8.5 to 12.6.

4. A method for the preparation of a modified Y-type molecular sieve, comprising the steps

of:

(1) contacting a NaY molecular sieve with a rare earth salt solution for ion-exchange reaction, to obtain an ion-exchanged molecular sieve, wherein the ion-exchange reaction is conducted under the following conditions:

a reaction temperature of 15 °C to 95 °C, a reaction time of 30 min to 120 minutes, and a mass ratio of the NaY molecular sieve, the rare earth salt, and water of 1: (0.01-0.18) : (5-20), wherein the mass of the NaY molecular sieve is calculated on a dry basis, and the mass of the rare earth salt is calculated on the basis of rare earth oxide;

(2) subjecting the ion-exchanged molecular sieve to a hydrothermal ultra-stabilization treatment by roasting at a temperature of 350 °C to 480 °C in an atmosphere comprising 30% to 90% by volume of steam for 4.5 h to 7 h, to obtain a hydrothermally ultra-stabilized molecular sieve;

(3) subjecting the hydrothermally ultra-stabilized molecular sieve to a gas phase ultra-stabilization treatment by contacting and reacting with gaseous $SiCl_4$, to obtain a gas phase ultra-stabilized molecular sieve;

(4) subjecting the gas phase ultra-stabilized molecular sieve to an acid treatment by contacting with an acid solution, to obtain an acid-treated molecular sieve;

(5) subjecting the acid-treated molecular sieve to phosphorus modification by contacting with a phosphorus compound, to obtain a phosphorus-modified molecular sieve; and

(6) impregnating the phosphorus-modified molecular sieve with a zinc salt solution, to obtain the modified Y-type molecular sieve.

5. The method according to claim 4, wherein in the step (3), the reaction temperature is 200 °C to 650 °C, the reaction time is 10 minutes to 5 hours, and the mass ratio of $SiCl_4$ to the hydrothermally ultra-stabilized molecular sieve is (0.1-0.7) : 1, wherein the mass of the hydrothermally ultra-stabilized molecular sieve is calculated on a dry basis.

6. The method according to claim 4 or 5, wherein in the step (4), the acid treatment is carried out at a temperature of 60 °C to 100 °C for a period of 1 hour to 4 hours;

preferably, the step (4) further comprises contacting and reacting the gas phase ultra-stabilized molecular sieve with an acid in an aqueous solution, wherein the mass ratio of the acid to the gas phase ultra-stabilized molecular sieve is (0.001- 0.15) : 1, the mass ratio of water in the aqueous solution to the gas phase ultra-stabilized molecular sieve is (5-20) : 1, and the mass of the gas phase ultra-stabilized molecular sieve is calculated on a dry basis.

7. The method according to claim 6, wherein the acid comprises one or more of organic

acids and inorganic acids, and wherein the mass ratio of the inorganic acid to the gas phase ultra-stabilized molecular sieve is (0.001-0.05) : 1, and the mass ratio of the organic acid to the gas phase ultra-stabilized molecular sieve is (0.02-0.10) : 1;

preferably, the organic acid is one or more selected from the group consisting of oxalic acid, malonic acid, succinic acid, methyl succinic acid, malic acid, tartaric acid, citric acid, and salicylic acid; and/or

preferably, the inorganic acid is one or more selected from the group consisting of phosphoric acid, hydrochloric acid, nitric acid, and sulfuric acid.

8. The method according to any one of claims 4 to 7, wherein in the step (5), the phosphorus modification is conducted at a temperature of 15 °C to 100 °C for a period of 10 min to 100 min;

preferably, the phosphorus compound used for the phosphorus modification is one or more selected from the group consisting of phosphoric acid, ammonium phosphate, ammonium dihydrogen phosphate, and diammonium hydrogen phosphate.

9. The method according to any one of claims 4-8, wherein the step (6) further comprises subjecting the impregnated molecular sieve to calcination, wherein the impregnation temperature is 10 °C to 60 °C, the calcination temperature is 350 °C to 600 °C, and the calcination time is 1 hour to 4 hours.

10. A catalytic cracking catalyst, comprising, based on the weight of the catalyst on a dry basis, 10% to 50% by weight of a modified Y-type molecular sieve, a binder, and clay; wherein the modified Y-type molecular sieve is a modified Y-type molecular sieve according to any one of claims 1 to 3 or a modified Y-type molecular sieve obtained by the method according to any one of claims 4-9.

11. The catalytic cracking catalyst according to claim 10, wherein the catalyst comprises 10% to 50% by weight of the modified Y-type molecular sieve, 10% to 40% by weight of a binder and 10% to 80% by weight of clay, based on the weight of the catalyst on a dry basis;

preferably, the clay is selected from the group consisting of kaolin, hydrated halloysite, montmorillonite, diatomaceous earth, halloysite, saponite, rector, sepiolite, attapulgite, hydrotalcite, bentonite, and any combination thereof; and/or

preferably, the binder is an alumina binder selected from the group consisting of alumina, hydrated alumina, aluminum sol, and any combination thereof, and the content of the binder is calculated on the basis of alumina.

12. Use of a modified Y-type molecular sieve according to any one of claims 1 to 3 in the

catalytic cracking of a hydrocarbon feedstock, comprising contacting the hydrocarbon feedstock with a catalytic cracking catalyst comprising the modified Y-type molecular sieve under catalytic cracking conditions.

13. The use according to claim 12, wherein the hydrocarbon feedstock is a hydrogenated light cycle oil, and the catalytic cracking conditions include: a reaction temperature of 500 °C to 610 °C, a weight hourly space velocity of 2 h^{-1} to 16 h^{-1}, and a catalyst-to-oil weight ratio of 3 to 10.