Solid Acid Materials for Industrial Catalysis

Appearance and general characteristics
Luxfer MEL Technologies supplies a wide range of zirconium compounds (hydroxides and oxides) for different industrial chemical processes, including hydrogenation, biomass conversion, isomerization and alkylation; offering attractive advantages in properties, e.g. thermal stability, various particle sizes, porosity and acidity.

Materials are solid white powders, odorless, with the dopant content 0-30 wt%. A wide range of dopants are available.

Advantages

Easy separation from reaction media
Catalysts can be easily separated from the reaction media. They do not form non-desirable by-products.

High activity
Catalysts show good catalytic activity due to their high acidity, which is stronger than 100% H$_2$SO$_4$ (Hammett function H$_0$=-14-16). Also they have developed porosity and defined crystalline structure.

Resistance to poisoning
Catalysts can tolerate up to 20ppm water in the feed, and also higher levels of benzene and C7+ straight chain fractions in refinery applications.

Reusability
Catalysts can be used several times during reaction cycle.

Low temperature operation
Zirconia superacids operate in the temperature range 120-190 °C, which is significantly lower than other catalysts e.g. zeolites (250-280 °C).

Environmentally friendly
Zirconia superacids do not release any halogen containing or other compounds which might corrode equipment.

Mode of action
The catalytic cycle of the acid catalyzed isomerization involves chain initiation to form the first active carbenium ion species, carbenium ion rearrangement and the chain propagation. Solid acid catalysts release proton, which favors to alkene protonation to form active carbenium ion.

Alkylation of isobutane with light olefins in the presence of solid acid catalyst is based on the series of consecutive reactions occurring through carbocation intermediates. The addition of proton (from solid acid catalyst) to an olefin leads to a t-butyl cation formation, which then combines with an olefin (e.g. C4) to give the corresponding C8 carbocation, which may isomerize via hydride transfer and methyl shifts to form more stable cations.

How to use solid acid materials
Amorphous sulfated zirconium hydroxides need activating by calcining at 500-600 °C; tungstated – 500-700 °C (preferably in static air) for 2-3 h immediately before use. The optimum temperature will depend upon the acidity requirements of the reaction being catalyzed. Calcined materials (e.g. oxides) should be dried at 300 °C for 1 h immediately before use.
Acidity characteristics of solid acid materials
R1, R2 –commercial grades; R3- new generation of
development materials

![Graph showing MS signal for different grades of materials](image1)

Figure 1. Propene 41 amu MS signal – TGA-MS.

Sulphated zirconia structure

![Diagram of sulphated zirconia structure](image2)

Tungstated zirconia structure

![Diagram of tungstated zirconia structure](image3)

References
1. Green Chemistry, 6, 2014
2. Catalysis Today, 329, 2019

Discover more at
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