Customized precursors for catalyst synthesis

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Introduction

Silica and alumina are materials of considerable practical importance in the catalysis industry. They are used as binders to support active catalytic components (metals or zeolites) where they sometimes bring additional catalytic functions or as precursor materials for the production zeolite with or without structure directing agent (SDA) sometimes referred to as template. The influence of physicochemical characteristics of silica, alumina and their mixtures on the crystallization and catalytic properties of the final catalyst has been the object of many studies[1234]. Results have shown that the chemistry, morphology, structure and homogeneity of the individual precursors and their mixtures have a significant impact on the crystallization kinetics and physicochemical characteristics of the resulting catalyst materials. The aim of this work is to develop precursors physically and chemically designed to provide optimum crystallization kinetics, yield and catalytic properties of zeolites and molecular sieves.

Materials and Methods

The present work describes the development of precursor materials with the objective to obtain silica, alumina and SDA precursor materials in various controlled physicochemical forms and state of homogeneity. These precursors are prepared from chemical modifications of typical colloidal silica production processes[56] including the neutralization of sodium silicate followed by the nucleation and the polymerization of silica. Investigations of the modified precursors were investigated by ammonia desorption, Electron Energy-Loss Spectroscopy, X-Ray diffraction, 27Al MAS NMR to confirm the chemical mapping of the components macroscopically and at a nanoscale level and their chemical effects on the properties of the final precursor.

Results and Discussion

The introduction of metal during the polymerization growth of silicate has led to a modification of surface chemistry on the final particles. Specifically, the addition of Aluminum during the colloidal silica polymerization provides additional acidity on the surface of the particles as shown in **Figure 1**. Further investigations have shown that most aluminum atoms introduced are substituted to silicon in the silica network, are uniformly dispersed throughout the colloidal particles. It is shown that, the substitution confers both Brønsted and Lewis based acidity to the colloidal particles. Introduction of organic materials prior to, during and after polymerization of colloidal silica has also been carried out. The introduction of polyamines results in colloidal particles showing a multifunctional surface activity confirming the inclusion of the organic group at the particles surface.

The chemistry of colloidal silica under specific conditions allows for the addition and coating of certain metal salts and organic compounds. In particular, the addition of aluminum acetate into a solution of colloidal silica provides a stable suspension of positively charged silica particles onto which Al is under the monomeric form $[AlOH(H_2O)_5]^{2+}$ at the surface of the particles.

Multiple other discrete and/or continuous configurations of the components can be designed from the technologies developed during this work.

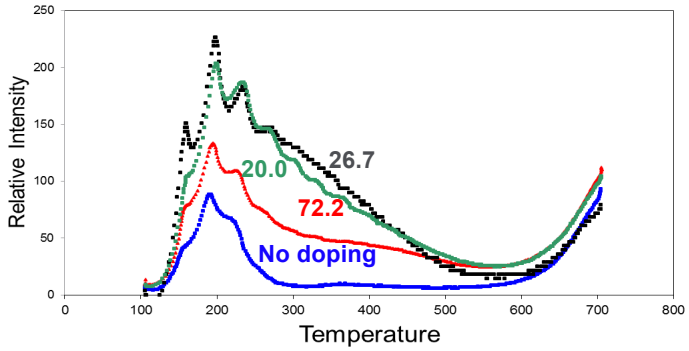

Figure 1. Ammonia chemisorption as a function of SiO2/Al2O3 mole ratio

Significance

The availability of silica, alumina and organic precursors and mixtures thereof in various state of chemical, physical and homogeneousness have been reported to exert a significant influence on the kinetics of crystallization of zeolite and the activity of catalytic materials. The above mentioned precursors act as a customized colloid approach to catalyst material. A direct example of application of these technologies find itself in a dramatic reduction of the amount of structuring agent and the production cost the material.

References

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