Patcharin Worathanakul 2008: Novel Synthesis of Nanostructured Materials: SiO_2-TiO_2, SiO_2-Al_2O_3 and SUZ-4 Zeolite for Environmental Applications. Doctor of Engineering (Chemical Engineering), Major Field: Chemical Engineering, Department of Chemical Engineering. Thesis Advisor: Associate Professor Paisan Kongkachuichay, Ph.D. 164 pages.

This research focuses on the synthesis and characterization of nanostructured materials. The aim of these studies is to synthesize SUZ-4 zeolite from sol-gel synthesis and synthesize SiO_2-TiO_2 and SiO_2-Al_2O_3 by a flame aerosol route. The application of these materials was used as nanostructured sorbents in a differential bed reactor for elemental mercury (Hg^0) capture by heterogeneous gas-solid reaction. Furthermore, photocatalytic degradation of methyl orange dye was also studied.

First, hydrothermal sol-gel synthesis of SUZ-4 zeolite with tetraethlyammonium hydroxide as the template was studied. The effect of SiO_2: Al_2O_3, TEA_2O: Al_2O_3, H_2O:Al_2O_3, K_2O:Al_2O_3 ratios, rotating or stirring, crystallization time and temperature were identified as a domain for pure SUZ-4 synthesis. The suitable SUZ-4 formation from this study takes place for SiO_2:Al_2O_3 ratio of 21.2 for 4 days at 155 °C crystatllization under autogenous pressure. It clearly possessed a high micropore volume at 0.1089 cm^3/g, 440.4 m^2/g BET surface area, narrow pore size distribution with 0.07 μm mean diameter and 0.64 μm long of needle crystal shape. A new SUZ-4 zeolite membrane has been produced under this condition in rotating autoclave reactor and need to develop for further study. Second, a flame aerosol reactor was used to synthesize SiO_2-TiO_2 and SiO_2-Al_2O_3. The processing conditions were identified for synthesis of different crystal phase at different precursor molar ratios. The results showed that the addition of SiO_2 inhibited TiO_2 phase transformation from anatase to rutile. The different morphology mainly was the result of changing the quench ring position for SiO_2-TiO_2 system. Quenching can stop the growth kinetics, and this was obtained by locating the quench ring at different positions in the particle formation process. At lower positions, SiO_2-TiO_2 was obtained in a core-shell structure. The difference in residence time for sintering and coalescence yielded different morphology. In contrast, only solid-solid solution was formed in SiO_2-Al_2O_3 system. The results from FTIR confirmed the existence of Si-O-Ti and Si-O-Al bonding for all samples of SiO_2-TiO_2 and SiO_2-Al_2O_3 systems, respectively. The SiO_2-TiO_2 samples exhibited better dispersion than pure TiO_2 and SiO_2-Al_2O_3 nanostructured composite were also better dispersion than pure single (SiO_2 or Al_2O_3) component confirmed by zeta potential measurements.

Following synthesis of these nanomaterials for environmental application, elemental mercury (Hg^0) capture by heterogeneous gas-solid reaction with nanostructured sorbents was studied in a differential bed reactor at room temperature. Elemental mercury capture efficiency of greater than 70 percent was observed for TiO_2, TiO_2 pillared clay (PILC), SUZ-4 zeolite, and one of the commercial iron oxides on irradiation with UV light for an inlet mercury concentration of 75±1.9 $\mu g/m^3$. The initial rate of Hg^0 capture per unit mass of sorbent was highest for TiO_2. The mercury associated with one of the commercial iron oxides was more labile than the mercury associated with the other sorbents from the result of sequential extraction technique. TiO_2 shows the greatest potential as the sorbent to capture elemental mercury on irradiation with UV light based on the results of this study. Finally, for photocatalytic degradation of methyl orange dye, SiO_2-TiO_2 nanocomposite can suppress its photocatalytic degradation and increase its dispersion ability.

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Thesis Advisor's signature

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