Advanced materials based on ionic liquid thin film technology

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Novel Supported Ionic Liquid Phase (SILP) materials consist of an ionic liquid, dispersed as a thin film on the inner surface of a highly porous solid material. By dissolving homogeneous transition metal complexes in the ionic liquid film, the SILP concept allows tailor making of solid materials with definite properties and a controlled chemical reactivity. Since the ionic liquid is dispersed on the inner surface of the support, a dry solid material is obtained. These materials can be handled like classical heterogeneous catalysts or adsorbents and can be applied in established fixed-bed reactors, thus making these novel materials highly attractive for large scale applications.

When the support material itself is catalytically active, so-called "solid catalyst with ionic liquid layer" (SCILL) materials are obtained. Here, the ionic liquid adjusts, by its solubility properties, the local concentration at the active center. Additionally, the ionic liquid can interact with the catalyst and thereby modify the selectivity. Due to the extremely low vapor pressure of ionic liquids, both SILP and SCILL concepts are especially suited for continuous gas-phase reactions. No leaching of ionic liquid and catalyst can occur via the gas-phase and e.g. SILP catalysts remain intact under steady state conditions for more than 1000 hours time on stream. Since the catalyst is retained inside the reactor, only products and non-converted substrates leave the reactor, thus simplifying the downstream processing significantly.

The latest developments from SILP catalyzed gas-phase hydroformylation and water-gas shift reaction will be presented. Compared to the standard catalytic systems, superior performance with regard to activity, selectivity and stability is obtained, thus making these SILP catalysts highly attractive for industrial applications.

The SILP materials can also be applied in dedicated gas purification systems, making use of the ionic liquids' tunable solubility for certain compounds in the gas stream. Latest results from gas-phase desulphurization studies in which the sulfur compound butyl-mercaptan is absorbed in the ionic liquid film of the SILP material indicate the high potential for industrial applications. Easy regeneration of the SILP material was achieved by pressure and temperature swing cycles.

It is anticipated that SILP and SCILL technology will facilitate new and promising applications of homogeneous catalysts in gas-phase processes as well as sophisticated gas-purification scenarios both for the removal of hazardous gas components from exhaust streams or for the purification of valuable gases in a highly energy efficient manner.