Fine Chemical Transformation Using Heterogeneous Catalysis : on the Examples of Fragrances and Flavours

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In the development of new chemical processes the market requires two objectives to be fulfilled. One is the highest possible efficiency with respect to the raw materials including feed stock and energy. This leads to processes with high conversion and selectivities which refrain from expensive separation procedures downstream. The key to high yields is an active and selective catalyst. The second objective for a new process is concerned with the vast number of environmental regulations. Any by-product that cannot be used as a feedstock in another process becomes immediately expensive waste which has to be disposed off. This has formed the public opinion that ecology and economy are contradictory objectives. But heterogeneous catalysis has proven for bulk chemicals that it can combine both claims. Recently , those considerations and concerns are applied for processes in the field of fine chemicals and intermediate chemicals .

The use of homogeneous Brønsted and Lewis- acids and bases was one of the main reasons for the production of high amounts of inorganic salts as by-products in industrial syntheses. For example, in the fine chemical industry and for the production of pharmaceuticals sometimes 50–150kg by-products per kg desired product are formed. Therefore new processes in the production of fine chemicals in order to reduce the high numbers of by-product formation are needed. In this respect heterogeneous catalysts can be of great use.

In this overview new heterogeneously catalyzed processes for the synthesis of industrially relevant fine chemicals on the example of fragrances and flavors will be presented. Such substances have been playing a dominating role stimulating the human senses. Starting as substances used for cultic and religious purposes, they found their way to the individual contribution to the improvement of the personal comfort. Among the oldest fragrances incense, myrrh as well as sandalwood and cedar wood are counted. Of the more than 5000 available fragrances nowadays, only 5 % are gained from natural sources. In most cases the demand can not be provided anymore by natural sources. In most cases the demand can not be provided anymore by natural sources. Therefore, a lot of fragrances, flavors and aromas are based on chemical compounds in the fragrance industry.

As an example an important class/category of compounds in this field are aldehydes and ketones. A very valuable method for the introduction of an aldehyde or ketone group in organic fine chemicals is the epoxidation of olefins and the following rearrangement of the oxiranes in the presence of acidic catalysts. Homogeneous catalysts such as phosphoric acid, BF_3, $FeCl_3$, $ZnBr_2$ and $SnCl_4$ as well as heterogeneous catalysts such as SiO_2, Al_2O_3, ZnO,WO_3, supported metals and various precipitated phosphates have been applied. The heterogeneous catalysts used in the past had some drawbacks such as incomplete conversion in most cases, low selectivity because of consecutive aldol condensation to form preferably trimers and low service time. Therefore, the fragrance industry still applies homogeneous catalysts in the manufacturing plants. Furthermore, in respect to the regioselectivity of the ring opening reaction of oxiranes electronic as well as steric factors can play a role. These general considerations stimulate to use zeolites and "non zeolitic" molecular sieves as heterogeneous catalysts for such rearrangement reactions in the liquid or in the gas phase in a slurry reactor and in a continuous fixed bed reactor, respectively.

Further examples for the syntheses of fragrances, flavors and aroms in the presence of heterogeneous catalyst will be given including the synthesis of p–cymene from renewable feedstock , campholenic aldehyde (a precursor of sandalwood fragrances) , synthesis of indoles and grapefruit aroma .

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