Mesoporous carbon as an efficient catalyst for alcoholysis and aminolysis of epoxides

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The ring opening reaction of epoxides by alcohols and amines using mesoporous activated carbon as efficient and environmentally friendly heterogeneous catalyst is reported. Carbon xerogels were synthesized by polymerization of resorcinal and formaldehyde. The surface of the activated carbon was oxidized in liquid phase with HNO3 and then functionalized with H2SO4. Chemical and textural characterization by elemental analysis, pHPCZ, TPD, BET and XPS indicates that oxidation in liquid phase is effective in the introduction of strong acid groups in the carbon surface. The functionalization with H2SO4 led to more acid functional groups, as expected. The activated carbons were tested in alcoholysis and aminolysis of epoxides, having been obtained excellent results of conversion and selectivity, both over 95%.

1. Introduction

For the sustainability of our ever evolving modern world it is necessary to keep looking for new and diverse ways to optimize the available resources. In this sense the development of new and less expensive heterogeneous catalysts and their application in reactions with synthetic interest such as the ring opening of epoxides is an important challenge with industrial repercussions.

Epoxides are versatile and valuable intermediates in organic synthesis. These oxygen heterocycles are significantly more reactive than other ethers due to the strain induced by the presence of the three-membered ring; thus, epoxides undergo ring-opening reactions with alcohols to give β-alkoxy alcohols [1,2], which may result in valuable organic solvents or be used as a synthetic route for the synthesis of relevant compounds such as antitumurals or immunosuppressives [3].

It is also possible to synthesize amino alcohols by the amination of epoxides, where the cleavage of the C–O bond occurs in the presence of an amine. β-Amino alcohols are of growing importance for the pharmaceutical industry for their role as treatment agents of several human disorders [4–6].

Among the possible synthetic approaches yielding these products, the ring opening reaction appears as a very attractive method due to its simplicity leading to the corresponding β-substituted alcohols in high yields.

Suitable epoxide ring opening catalysts include Lewis acids and bases, Brönsted acids, porphyrin complexes [1], triflates [7] and perchlorates [8] in homogeneous phase. Heterogeneous catalysts have also been reported among them polymer supported ferric chloride [9], aluminumdodecatungstophosphatophosphate [10] and AlKfT-5 [11].

Other methods use include electrochemical reaction with trimethylborane [12] and microwave assisted synthesis [13–15].

All these catalysts used in the alcoholysis or aminolysis of epoxides show some disadvantages such as high reaction temperature, prolonged reaction time, non-catalytic nature of the reagent, low conversion and low regioselectivity. Furthermore, some of them may become explosive, are expensive, need special conditions for their preparation and, in homogenous phase, have some problems for the separation, isolation and purification of the product. Thus, the development of new catalytic methods for the reaction under study is highly desirable.