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Recent advances in production of succinic acid from glucose using Nb-based zeolites nanocomposites

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PURPOSE OF THE ABSTRACT

One of the big challenges of the nowadays chemistry is the development of cleaner catalytic processes to convert biomass to multiple platform molecules as strategic precursors for valuable products. In this context wet oxidation (WO) of glucose (a cheaper and large available raw material by comparison with fructose) can be, in principle, a very appealing process since oxygen is the only reagent used and water - the reaction medium. Unfortunately, WO of glucose is a very unselective process and a large variety of C2-C4 products are formed in unsatisfactorily low individual yields [1]. The use of a selective catalyst can control this unselective process by favoring the formation of certain reactive oxygen species and promoting some pathways that would not take place in its absence. To achieve such a goal, the development of highly selective solid catalysts, easy to separate and recycle is necessary.

In this context, the main objective of this work was the design and development of Nb-based zeolite nanocomposites suitable for the glucose oxidation into valuable biochemicals such as succinic acid (SA, 1,4-butanedioic acid), which is one of the top 12 platform chemicals, with a wide industrial applications such as pharmaceuticals products, surfactants, detergents, green solvents and biodegradable plastics [2]. A series of Nb (0.02-0.05moles%)-Beta zeolites catalysts were prepared in two step consisting in i) dealumination of H-Beta zeolite by treatment with mineral acids, and ii) insertion of Nb in the hydrophobic dealuminated zeolite framework [3]. The catalysts were exhaustively characterized using XRD, Raman, XPS, DRIFT spectroscopy, CO2- and NH3-TPD and TG-DTA. Activity tests were carried out in a pressure autoclave by using aqueous solutions of glucose as raw material, in the temperature range of 160-180°C, with molecular oxygen as oxidant and at different reaction times. For comparison, pristine H-BEA zeolites with different Si/Al ratios (18 - 37.5) were also tested. The recovered products from the liquid phase were sylilated and analyzed by GC-MS.

The dealumination of Beta zeolite by nitric acid affect its crystallinity only in a low extend, as confirmed by the XRD patterns [5], while the insertion of Nb decreased the crystallinity from 100% (as considered for H-Beta 18) to 70.6%, for Nb(0.05)-Beta 18 (Figure 1). Also, XPS spectroscopy confirmed the presence of Nb(V) (207.3 eV) [4] in the exchanged BEA zeolites (Figure 2).

In accordance to the characterization results, the most probable state of Nb(V) corresponds to Nb(V)O-H where niobium is linked by Nb-OSi bonds to the zeolitic walls. The presence of these species highly increases the acid sites concentration with moderate strengths but also stabilize the zeolite, most probably by polarizing the framework.

The Nb-Beta catalysts are highly efficient for the selective oxidation of glucose to SA. Therefore, 80% selectivity to SA was obtained for a total conversion of glucose. Optimal catalytic features and reaction conditions as well as the catalytic performances - catalytic properties correlation with the catalytic results will be discussed in detail.

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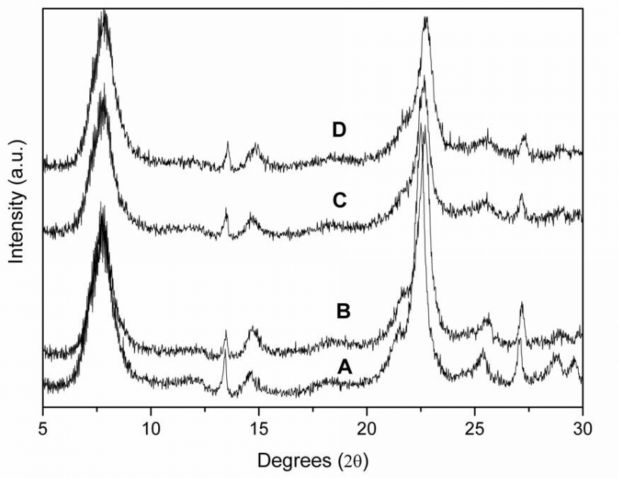
FIGURES



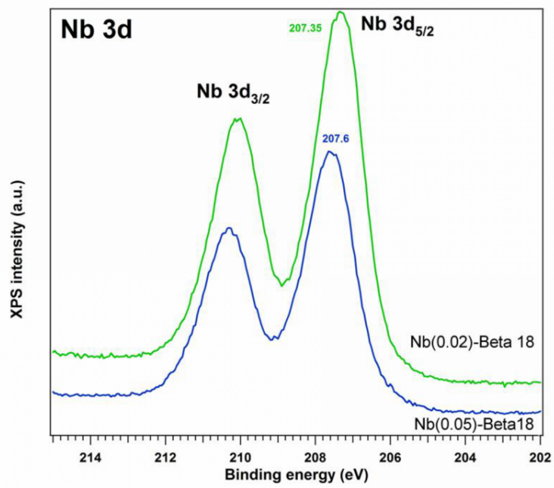


FIGURE 1

Figure 1

X-ray diffraction patterns of H-Beta 18 (A), SiBeta18 (B), Nb(0.02)-Beta18 (C) and Nb (0.05)-Beta18 (D)

FIGURE 2

Figure 2

XP Spectra of the Nb (3d) level for the Nb (0.02) and Nb (0.05)-Beta 18 samples

KEYWORDS

niobium | zeolite | glucose | succinic acid

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