Superior Stability of Au/SiO₂ Compared to Au/TiO₂ Catalysts for the Selective Hydrogenation of Butadiene

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Small Au particles are catalytically very active for several reduction and oxidation reactions, including the low-temperature oxidation of CO. In many cases reducible supports such as TiO₂ and CeO₂ lead to higher catalyst activities than when inert supports such as SiO₂ are used. Au is also a highly selective catalyst for the semi-hydrogenation of alkadiene impurities without further hydrogenation of the alkene stream, which is required for the production of industrial monomers. No large differences in activity have been observed on different supports, including TiO₂, CeO₂, ZrO₂ and Al₂O₃.¹ In this contribution we additionally report on using SiO₂ as a support, and especially discuss the influence of support properties on the longer term stability of these catalysts.

We compared supported gold catalysts with similar structural properties and morphology, and prepared using the same preparation strategy², but on supports of a different chemical nature: SiO₂ and TiO₂. We tested the activity, stability and selectivity of these 2–4 nm Au nanoparticulate catalysts for the hydrogenation of 0.3% butadiene in the presence of 30% propene (Figure 1). At full conversion of butadiene, only 0.1% of the propene was converted for both supported catalysts, demonstrating their high selectivity. The TiO₂-supported Au catalyst was initially much more active than the SiO₂ supported Au catalyst. However, a striking difference in catalyst stabilities was observed (Figure 1).

The TiO₂-supported Au catalysts showed a steady loss of activity, which was recovered by heating in air. We found that the deactivation is not due to significant metal particle growth or strong metal–support interaction. We demonstrated that instead it is due to the deposition of carbonaceous species under reaction conditions. In contrast, all the SiO₂-supported catalysts were highly stable, with very limited formation of carbonaceous deposits. It shows that SiO₂-supported catalysts, despite their 2–3 times lower initial activities, clearly outperform TiO₂-supported catalysts within a day of run time.

References

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