

Effect of the Activation Atmosphere on the Gold-Support Interaction in Au/Rutile Catalysts

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The stability of gold catalysts for the oxidation of CO depends on the interaction between the gold particles and the support [1]. Titania is one of the best supports for these catalysts [2]; when the titania is pure, however, the gold particles grow easily with time [3], reducing their catalytic activity. This can be hindered by supporting iridium particles before depositing the gold particles [4], or by doping the titania with iron [5].

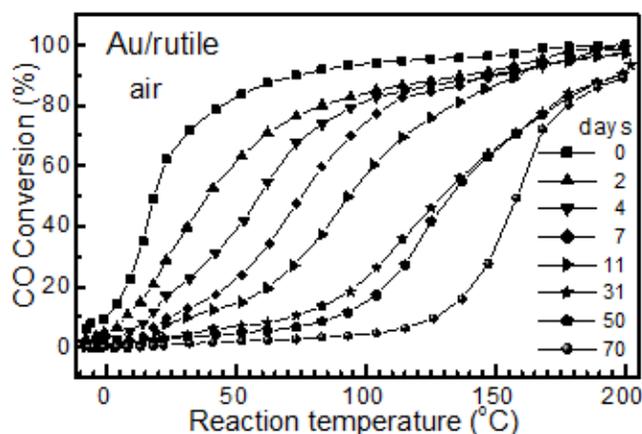


Figure 1. CO conversion as a function of time when the catalyst was activated in air.

In the present work we report the stabilization of gold particles supported on rutile through the atmosphere used to activate the catalyst.

When the activation occurs in air, the catalytic activity was strongly reduced after aging the catalyst for 11 days at room temperature in an air atmosphere (Figure 1). The catalysts activated in hydrogen were more stable (Figure 2).

Two factors cause the reduction of the catalytic activity: the increase of size of the gold crystallites, and their contamination with carbonate species (Figure 3).

The increase in size of the gold particles was irreversibly; consequently, the activity reduction caused by this increase was also irreversibly.

The reduction of the catalytic activity by the deposition of carbonate species on the gold particles was partially eliminated by heating the aged catalyst at 200 °C, first in air and then in hydrogen (Figure 4).

After this heat treatment to regenerate the catalysts, those activated in hydrogen recovered

about 60 % of their initial catalytic activity, while those activated in air recovered only 20 % of their initial activity (Figure 4), because in this last case the gold particles grew faster.

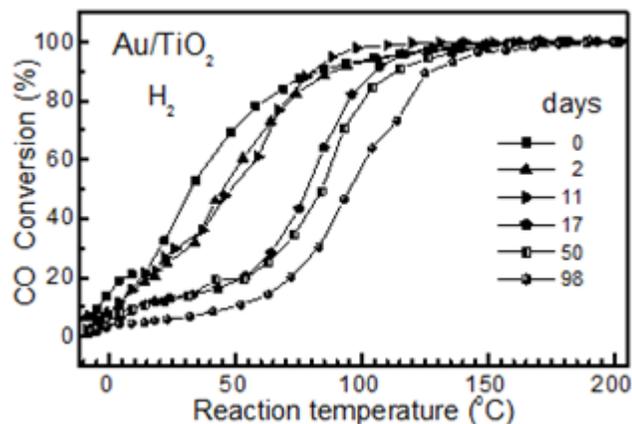


Figure 2. CO conversion as a function of time when the catalyst was activated in hydrogen.

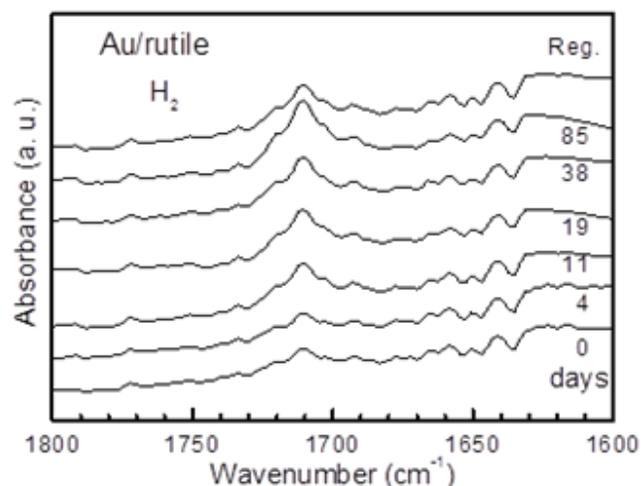


Figure 3. FTIR spectra of the aged samples activated in hydrogen. "Reg." refers to the regenerated catalyst.

The micrographs of the catalysts activated in air and in hydrogen show that in both types of catalysts the gold particles grew on the surface and at the edges of the support (Figure 5).

When the catalysts were activated in air, however, the gold particles on the surface of the support disappeared with time because they moved to the edges to fuse with the gold particles at these sites, increasing their dimensions (Figure 6B).

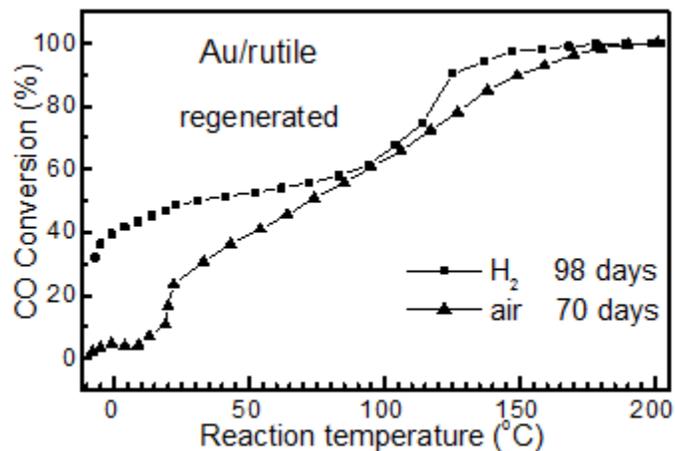


Figure 4. CO conversion after the regeneration of the catalysts.

In contrast, when the catalysts were activated in hydrogen, the gold particles that grew on the surface of the support did not move with time (Figure 6A).

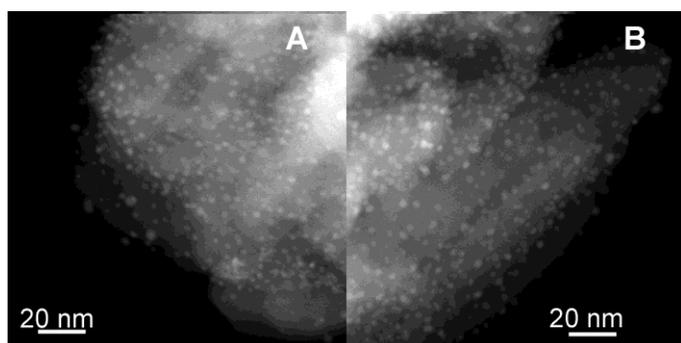


Figure 5. Z-contrast TEM micrographs of fresh catalysts: A) activated in hydrogen, B) activated in air.

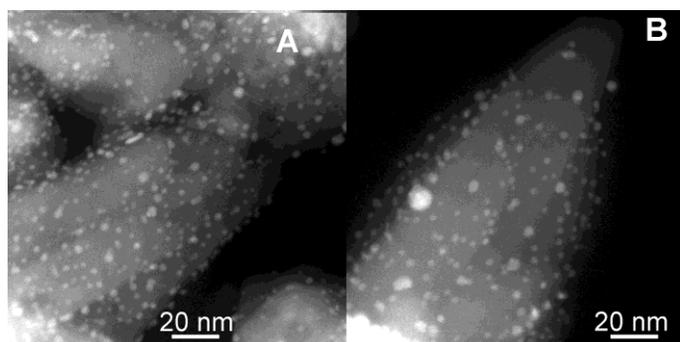


Figure 6. Z-contrast TEM micrographs: A) catalyst activated in hydrogen and aged in atmospheric air for 89 days; B) catalyst activated in air and aged in atmospheric air for 62 days.

These results indicate the presence of a strong interaction between the gold particles and the support when the catalysts were activated in hydrogen. This is because the activation in hydrogen partially reduced the support surface, favoring with that the interaction between the gold and the titanium atoms.

The interaction between the gold particles and the support was weaker when the catalysts were activated in air, because this interaction was mediated via the oxygen atoms of the support.

The above results were expected because the interaction between gold atoms and oxygen atoms is much weaker than the interaction between gold atoms and titanium atoms [6, 7].

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