Gold nanoparticles or clusters supported on titanium-containing supports are capable of epoxidizing propene to propene oxide (PO) by using hydrogen and oxygen at a high selectivity. However, propene formation may also happen or even prevail under certain circumstances: the particle size of gold supported on TiO$_2$ is smaller than 2 nm; or Ti-based oxides are used as supports while the gold size is out of the range of 2–5 nm; supported gold (+1) cyanide particles were reported to show a high selectivity toward propene hydrogenation. Significant propane formation is rarely reported when titanium silicalite-1 (TS-1) is used as the support. It was proposed that the contaminant of sodium on the catalysts is responsible for inhibiting propene hydrogenation on Ti-based gold catalysts.

Propene hydrogenation was encountered during our study into the site synergy between gold and titanium using Ti-SiO$_2$ as support. It was found that propene hydrogenation can be totally suppressed by adding small amount of carbon monoxide while propene epoxidation was not affected. Further investigation showed that the support itself plays an important role in propene hydrogenation since our gold particle size varied between 1 – 5 nm on different catalysts. Catalysts with similar gold/titanium loadings can give distinct performance in propene hydrogenation. Gold probably plays a role as providing hydrogen which spills over onto the support where the hydrogenation of propene may occur.

All catalysts that are active in propene hydrogenation show a similar pattern to the time-on-stream performance as shown in Figure 1, where the hydrogenation activity peaks at 170°C, a temperature corresponding to the temperature of dehydroxylation of titania and Ti-SiO$_2$. Figure 2 shows the UV–vis spectra of two catalysts with similar gold/titanium loadings and epoxidation activity but distinct activity in propene hydrogenation (A: 0.05wt% Au and 0.27wt% Ti; B: 0.05wt% Au and 0.21wt% Ti).

References