Supporting Information

Ruthenium nanoparticles supported over mesoporous TiO_2 as an efficient bifunctinal nanocatalyst for esterification of biomass-derived levulinic acid and transfer-hydrogenation reactions

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UV-Vis spectroscopy

Figure 3 showed the UV-visible diffuse reflectance spectra of mesoporous TiO_2 and $Ru@MTiO_2$. A broad absorption peak in the wavelength range 300-350 nm were observed for titania nanoctystal.[17] In case of $Ru@MTiO_2$, it exhibited a broad absorption peak in the visible range 600-800 nm due to wide range of visible absorption.[1]

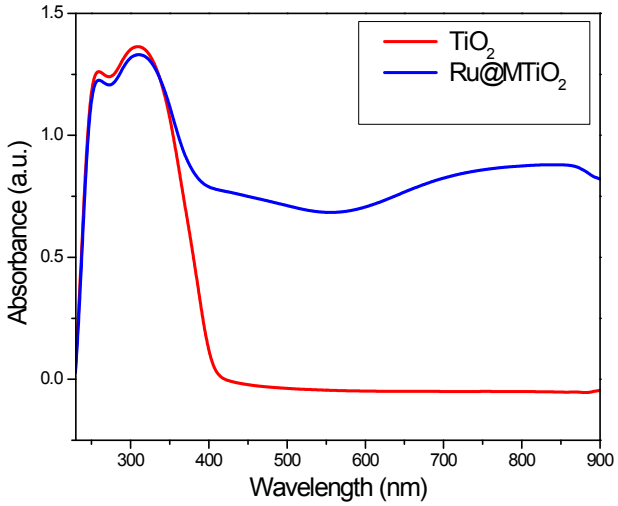

Figure S1. UV-Vis spectra of mesoporous TiO_2 and $Ru@MTiO_2$ nanomaterials.

Thermogravimetric analysis (TGA)

Figure S2 showed the TGA plots of mesoporous TiO_2 and Ru@MTiO_2 nanoparticles under N_2 flow. The TGA curve showed that *ca* 7% weight loss occurs up to *ca.* 103 ^oC due to desorption of physisorbed water. Decomposition of surfactant molecules starts from the temperature range of 103 ^oC to 376 ^oC and 3% weight loss observed on the surface of the nanoparticles. Again, the decomposition of the organic template starts from 376 ^oC to 593 ^oC and rapidly loses 6% of its weight. Then, weight loss of another ~ 1.0% occurs gradually till the temperature reached upto 800 ^oC. In case of Ru@MTiO_2 nanoparticles, same weight loss occurs up to 103 ^oC due to desorption of water. Only 2 % weight loss showed by Ru@MTiO_2 from 103 ^oC to 610 ^oC and less than 2% weight occurs up to 800 ^oC, which confirmed that Ru@MTiO_2 is more thermally stable than TiO_2 nanoparticle.

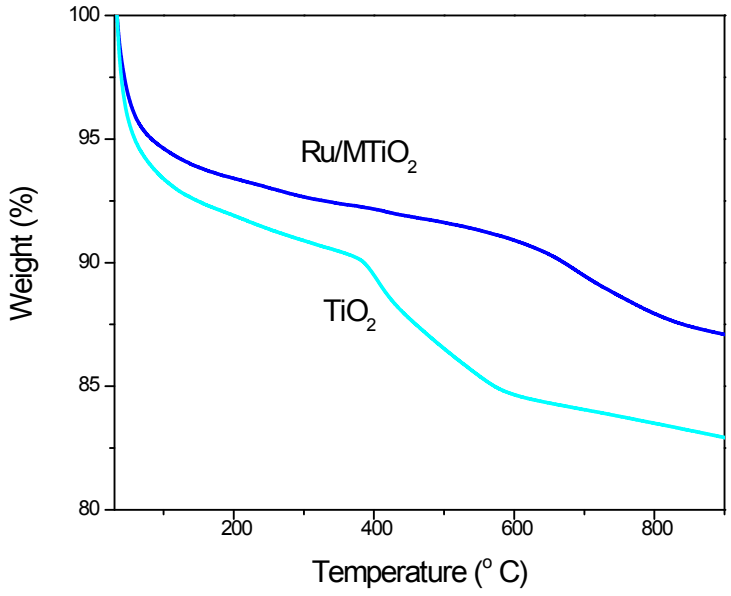

Figure S2. TGA plots of mesoporous TiO_2 and Ru@MTiO_2 nanomaterials.

^{1}H NMR data of esterification reactions:

Methyl levulinate (Table 1, entry 1): ^{1}H NMR (400 MHz, $CDCl_3$) δ ppm: 2.20 (s, 3H), 2.58 (t, J = 6.8 Hz, 2H), 2.77 (t, J = 6.4 Hz, 2H), 3.68 (s, 1H).

Ethyl levulinate (Table 1, entry 2): ^{1}H NMR (400 MHz, $CDCl_3$) δ ppm: 1.18 (t, J =7.2 Hz, 3H), 2.12 (s, 3H), 2.49 (t, J = 6.4 Hz, 2H), 2.68 (t, J = 6.4 Hz, 2H), 4.03-4.08 (m, 2H).

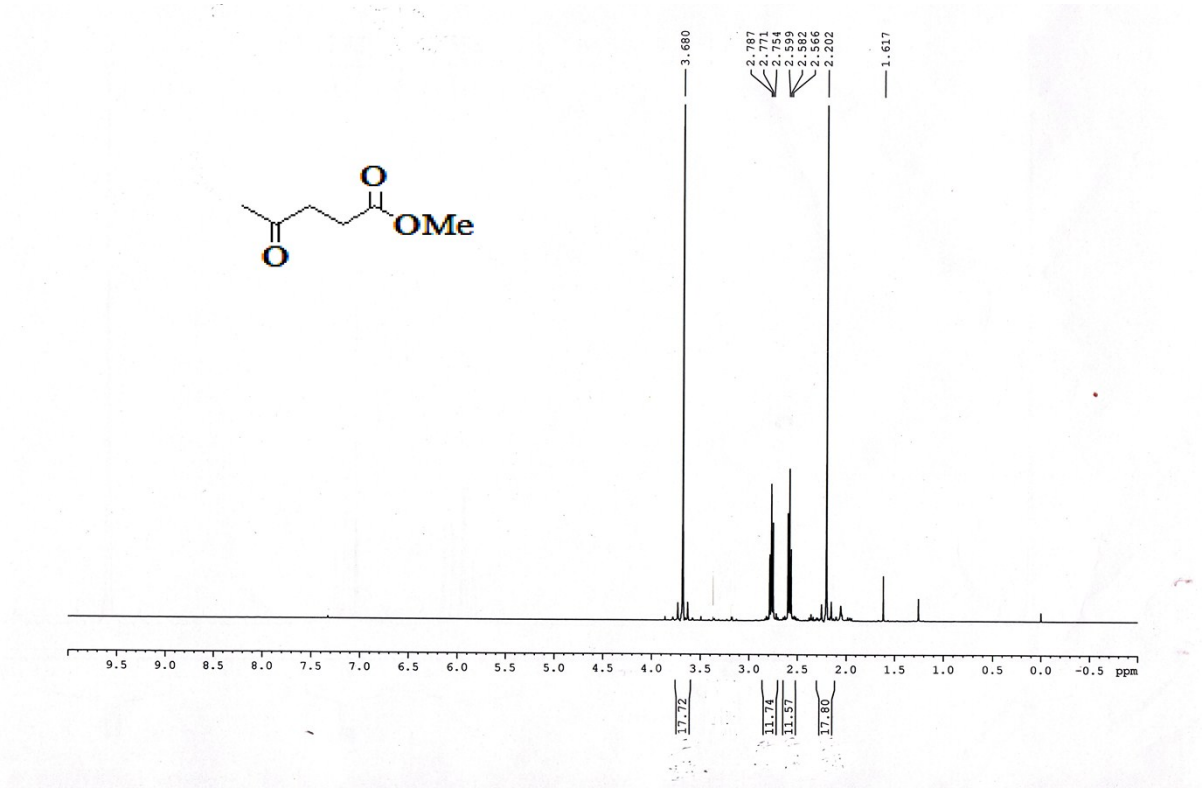

Figure S3. ^{1}H NMR spectra of methyl levulinate in $CDCl_3$.

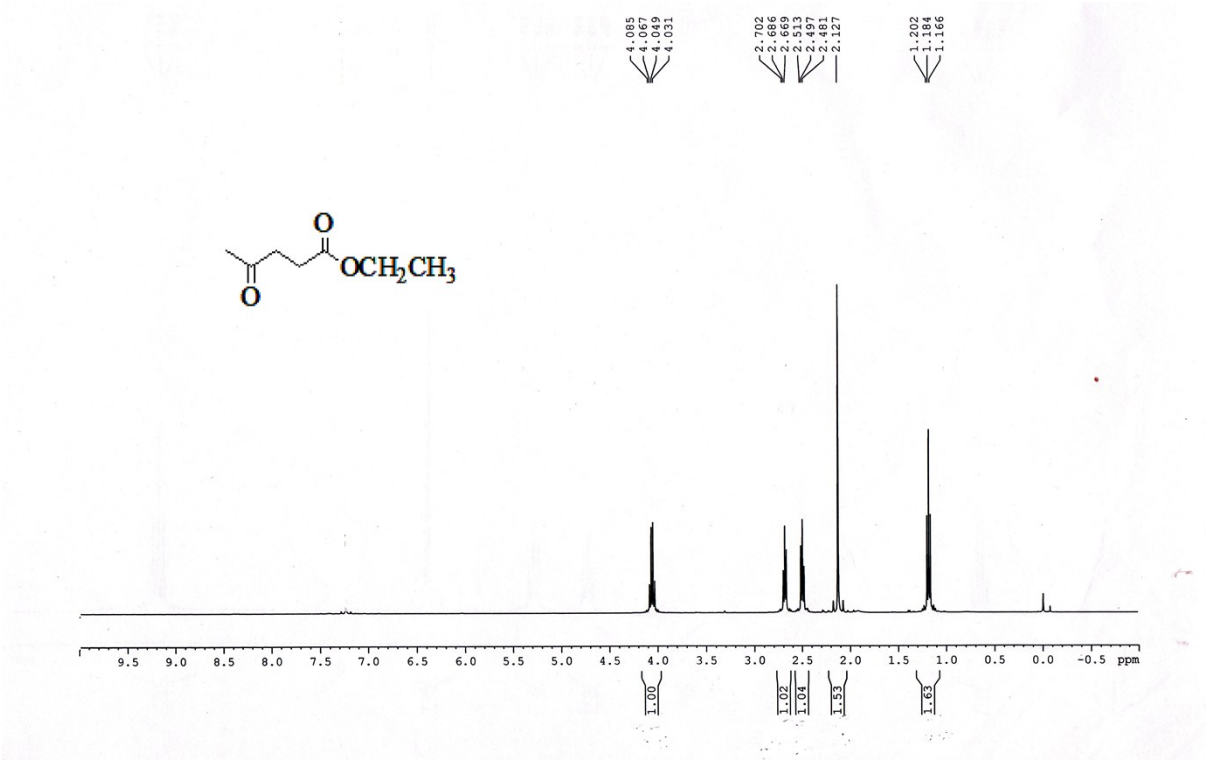

Figure S4. ^{1}H NMR spectra of ethyl levulinate in $CDCl_3$.

References

1. S. Bang, S. Lee, T. Park, Y. Ko, S. Shin, S.-Y. Yim, H. Seo and H. Jeon, *J. Mater. Chem*., 2012, **22**, 14141