Electronic Supplementary Material (ESI) for Green Chemistry.

Mesoporous sulfonic acid silicas for pyrolysis bio-oil upgrading via acetic acid esterification

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Catalyst characterisation

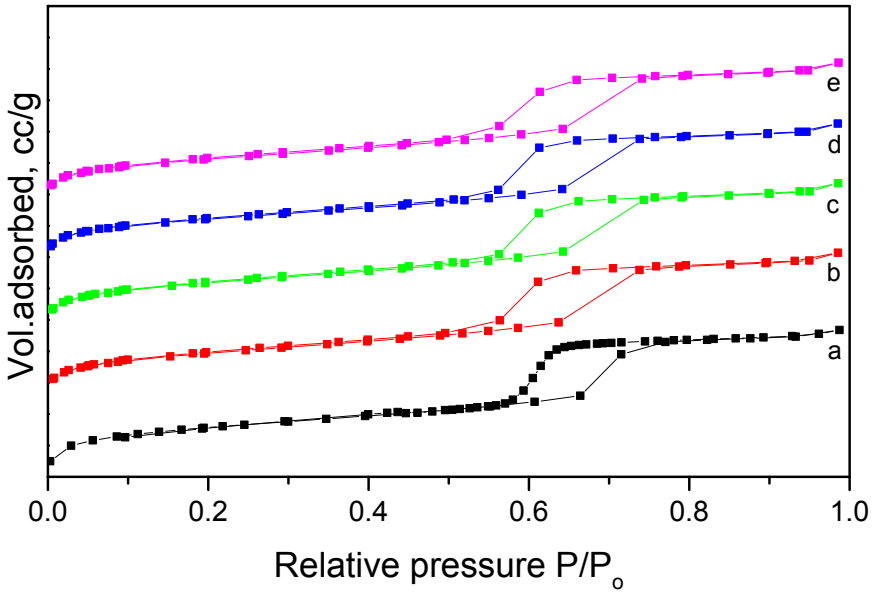

Fig. S1. Nitrogen adsorption-desorption isotherms of $PrSO_3H$/SBA-15 as a function of S loading: (a) SBA-15; (b) $PrSO_3H$(0.01ML)/SBA-15; (c) $PrSO_3H$(0.1ML)/SBA-15; (d) $PrSO_3H$(0.5ML)/SBA-15; (e) $PrSO_3H$(1ML)/SBA-15.

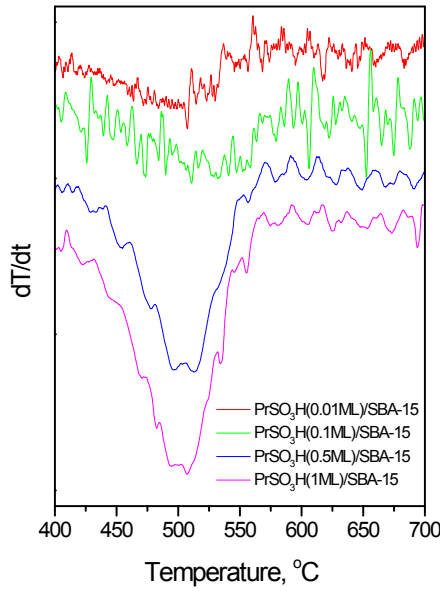

Fig. S2. Differential thermogravimetric profiles of $PrSO_3H$/SBA-15 as a function of S loading highlighting propylsulfonic acid decomposition between 400-600 °C.

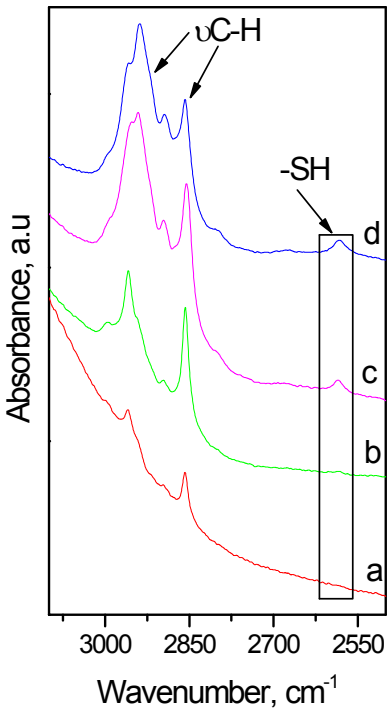

Fig. S3. DRIFT spectra of MPTMS functionalised SBA-15 as a function of S loading: (a) $PrSO_3H$(0.01ML)/SBA-15, (b) $PrSO_3H$(0.1ML)/SBA-15, (c) $PrSO_3H$(0.5ML)/SBA-15, (d) $PrSO_3H$(1ML)/SBA-15.

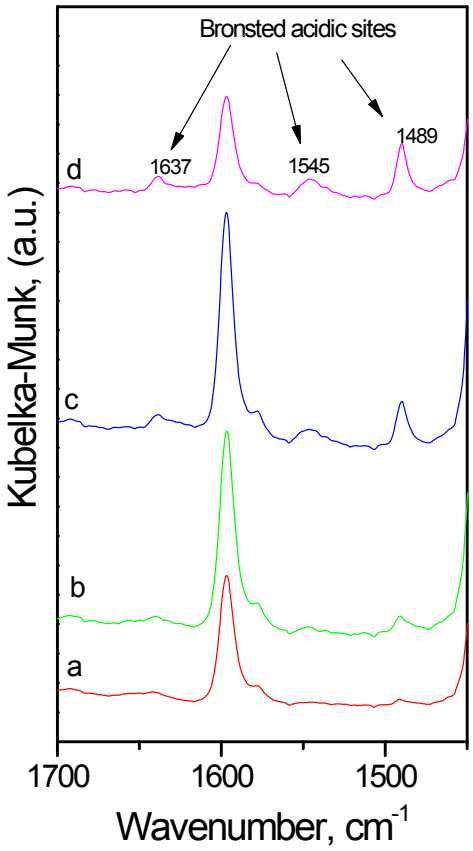

Fig. S4. DRIFT spectra of pyridine titrated $PrSO_3H$/SBA-15 as a function of S loading: (a) $PrSO_3H$(0.01ML)/SBA-15, (b) $PrSO_3H$(0.1ML)/SBA-15, (c) $PrSO_3H$(0.5ML)/SBA-15, (d) $PrSO_3H$(1ML)/SBA-15.

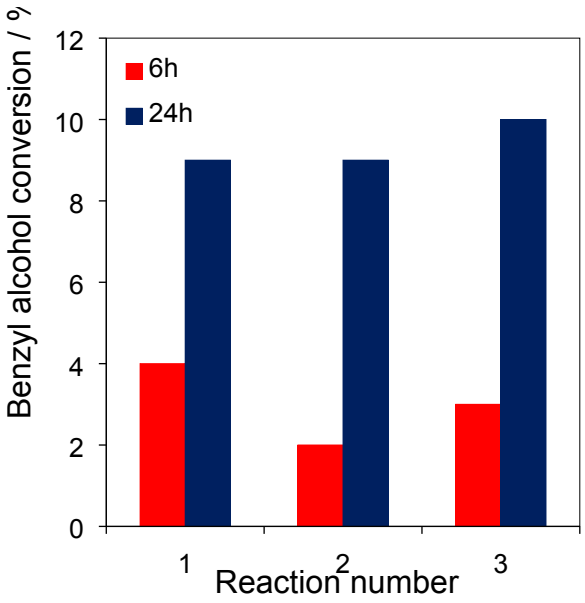

Fig. S5. Control reactions for acetic acid esterification with benzyl alcohol in the absence of catalyst. Reaction conditions: 100 °C, acid:alcohol = 2:1, toluene solvent.

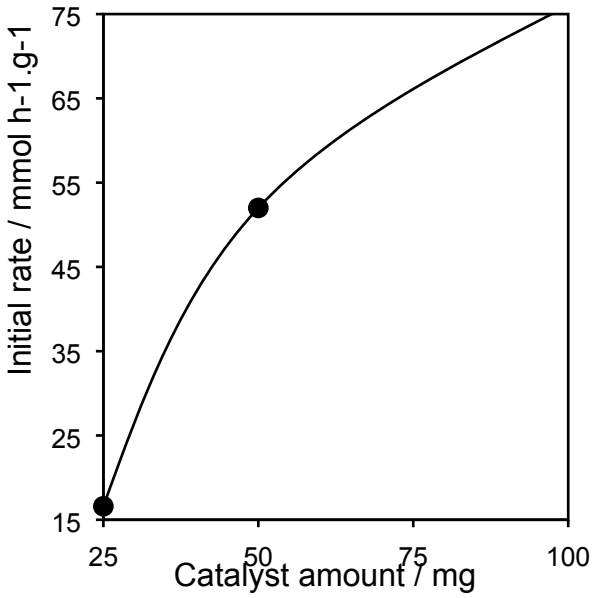

Fig. S6. Dependence of acetic acid esterification with benzyl alcohol on catalyst charge over $PrSO_3H$(1ML)/SBA-15. Reaction conditions: 100 °C, acid:alcohol = 2:1, toluene solvent.

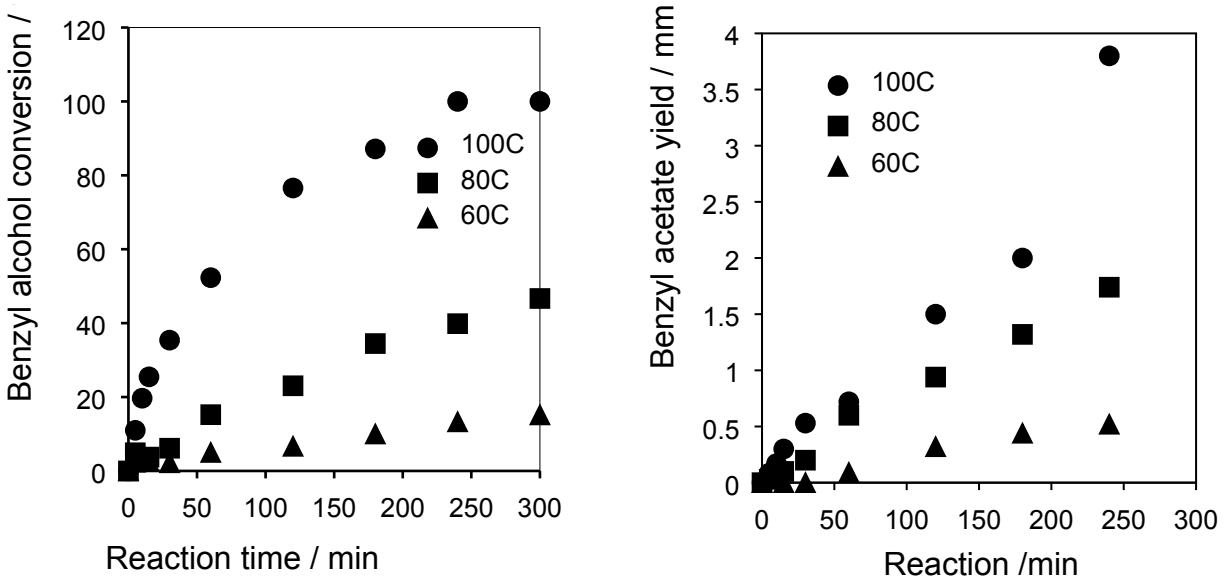

Fig. S7. Dependence of acetic acid esterification with benzyl alcohol over $PrSO_3H$(1ML)/SBA-15 on reaction temperature. Reaction conditions: 50 mg catalyst, acid:alcohol = 2:1, toluene solvent.

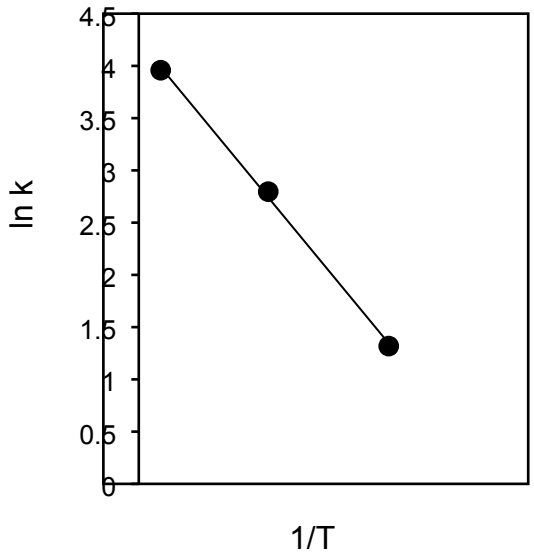

Fig. S8. Arrhenius plot for acetic acid esterification with benzyl alcohol over $PrSO_3H$(1ML)/SBA-15. Reaction conditions: 50 mg catalyst, acid:alcohol = 2:1, toluene solvent.

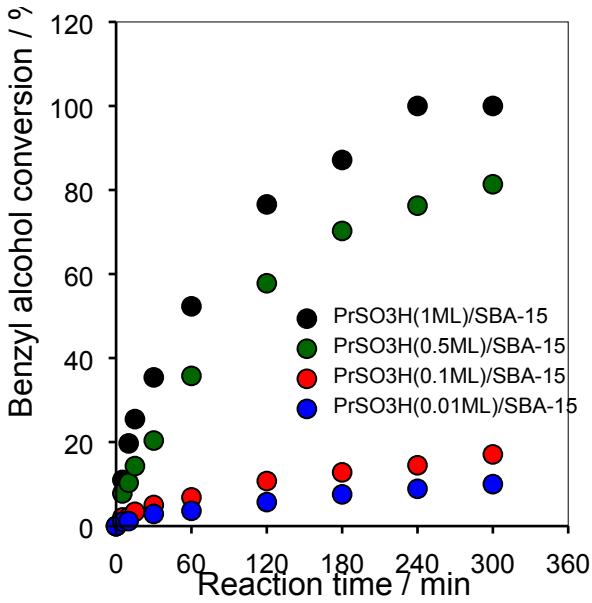

Fig. S9. Acetic acid esterification with benzyl alcohol over PrSO3H/SBA-15 as a function of S loading. Reaction conditions: 100 °C, 50 mg catalyst, acid:alcohol = 2:1, toluene solvent.

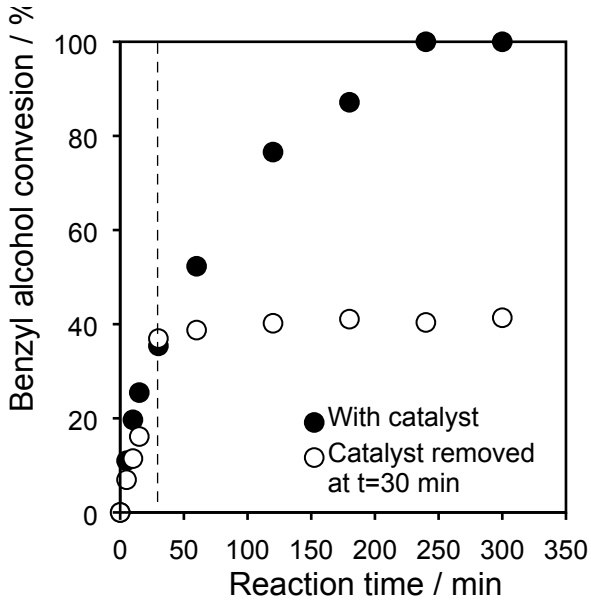

Fig. S10. Acetic acid esterification with benzyl alcohol with and without PrSO3H(1ML)/SBA-15 removal. Reaction conditions: 100 °C, 50 mg catalyst, acid:alcohol = 2:1, toluene solvent.

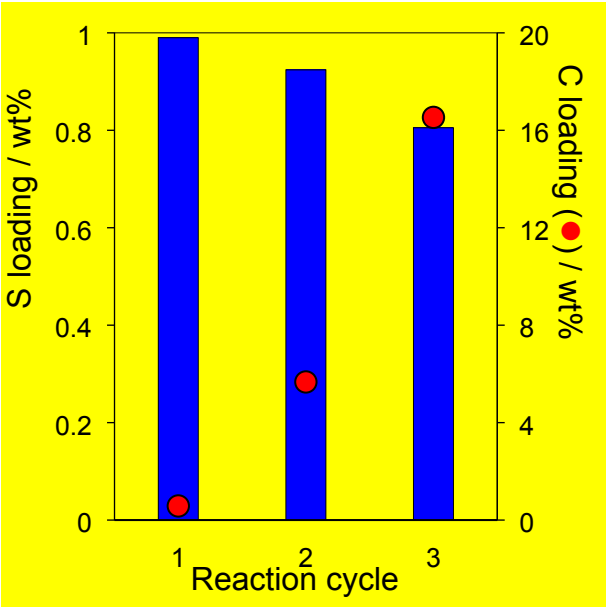

Fig. S11. Impact of acetic acid esterification with benzyl alcohol over $PrSO_3H$(1ML)/SBA-15 on catalyst composition as a function of re-use. Reaction conditions: 100 °C, 50 mg catalyst, acid:alcohol = 2:1, toluene solvent; spent catalysts washed with cold toluene and subsequently methanol between each cycle to remove weakly bound adsorbates.

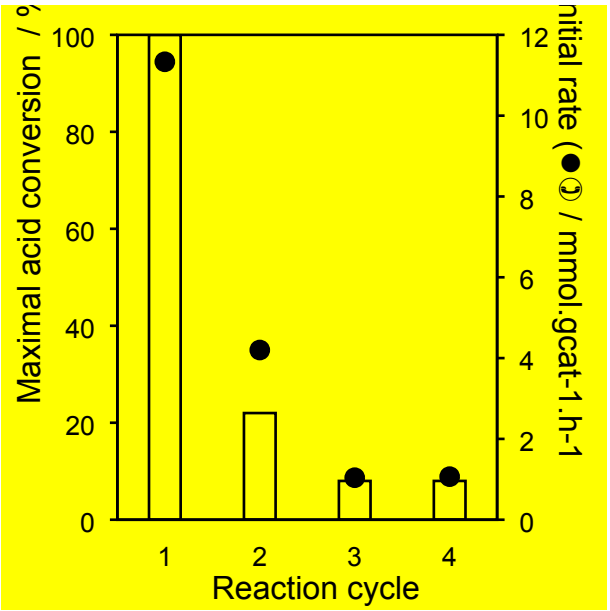

Fig. S12. Impact of catalyst re-use on acid esterification with benzyl alcohol over $PrSO_3H$(1ML)/SBA-15. Reaction conditions: 100 °C, 50 mg catalyst, acid:alcohol = 2:1, toluene solvent; spent catalysts washed with cold toluene and subsequently methanol between each cycle to remove weakly bound adsorbates.