

Supplementary material

Transformation of triglycerides to fatty acid methyl esters with hydrophilic sulfonated silica ($\text{SiO}_2\text{-SO}_3\text{H}$) as catalyst and quaternary ammonium salts in toluene or DMSO

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Abstract: Triglycerides of waste cooking oil reacted with methanol in refluxing toluene to yield mixtures of diglycerides, monoglycerides and fatty acid methyl esters (FAMES) in the presence of 20% (w/w) catalyst/oil using the hydrophilic sulfonated silica ($\text{SiO}_2\text{-SO}_3\text{H}$) catalyst alone or with the addition of 10% (w/w) co-catalyst/oil $[(\text{Bu}_4\text{N})](\text{BF}_4)$ or Aliquat 336]. The addition of the ammonium salts to the catalyst lead to a decrease in the amounts of diglycerides in the products, but the concentrations of monoglycerides

increased. Mixtures of $[(\text{Bu}_4\text{N})](\text{BF}_4)/\text{catalyst}$ were superior to catalyst alone or Aliquat 336/catalyst for promoting the production of mixtures with high concentrations of FAMEs. The same experiments were repeated using DMSO as the solvent. The use of the more polar solvent resulted in excellent conversion of the triglycerides to FAME esters with all three-catalyst media. A simplified mechanism is presented to account for the experimental results.

Keywords: hydrophilic sulfonated silica catalyst; Aliquat 336; tetrabutylammonium tetrafluoroborate; transesterification; fatty acid methyl esters, DMSO.

Copies of spectra

1) Waste cooking oil

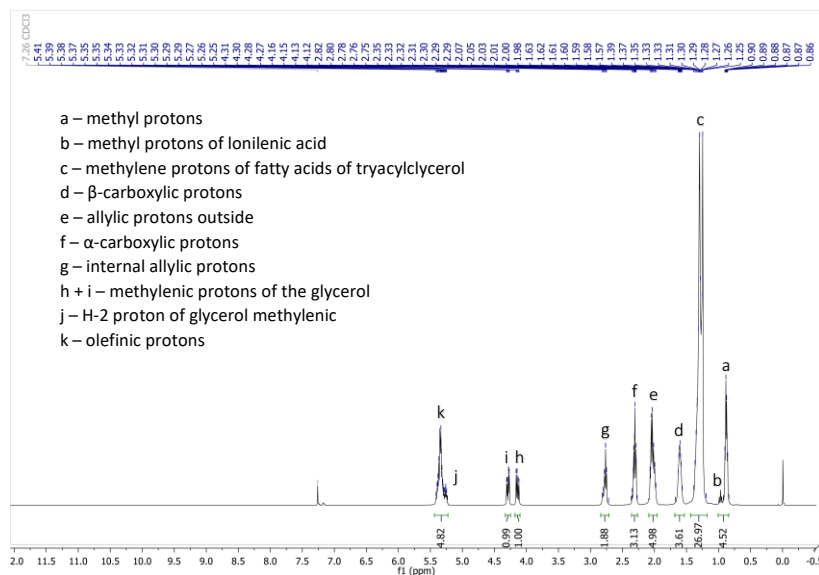


Figure S1. ¹H NMR waste cooking oil.

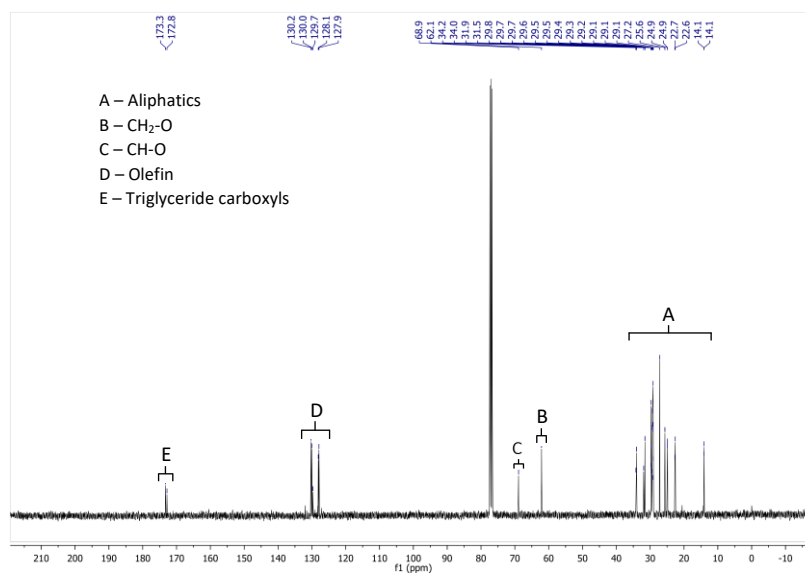


Figure S2. ¹³C NMR waste cooking oil.

2) FAME (Fatty acid methyl ester)

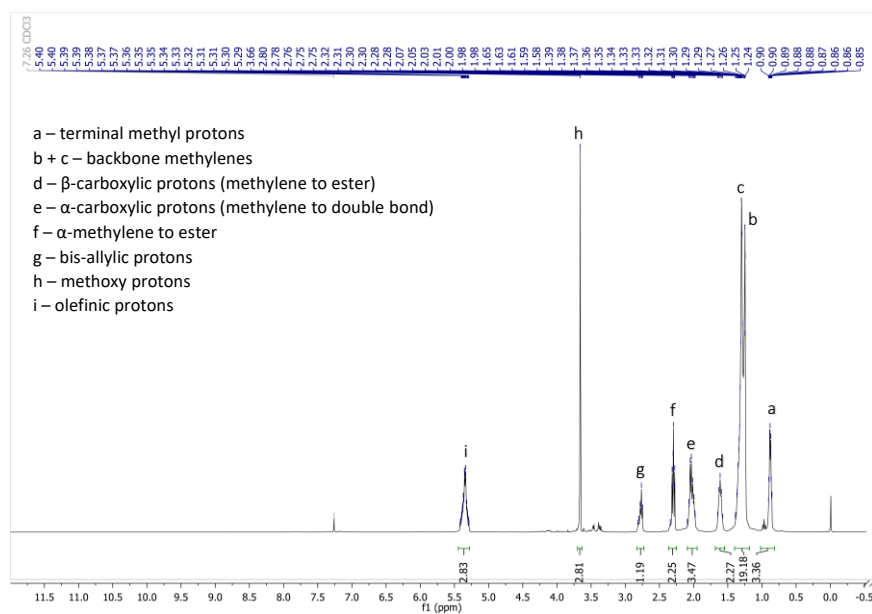


Figure S3. ^1H NMR Fatty acid methyl ester using $\text{SiO}_2\text{-SO}_3\text{H}$ as catalyst.

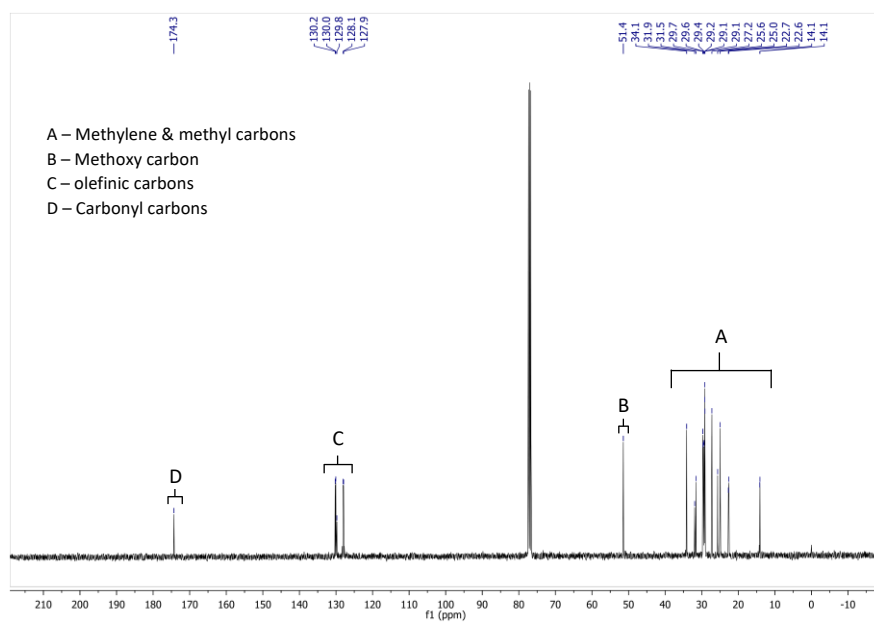


Figure S4. ^{13}C NMR Fatty acid methyl ester using $\text{SiO}_2\text{-SO}_3\text{H}$ as catalyst.

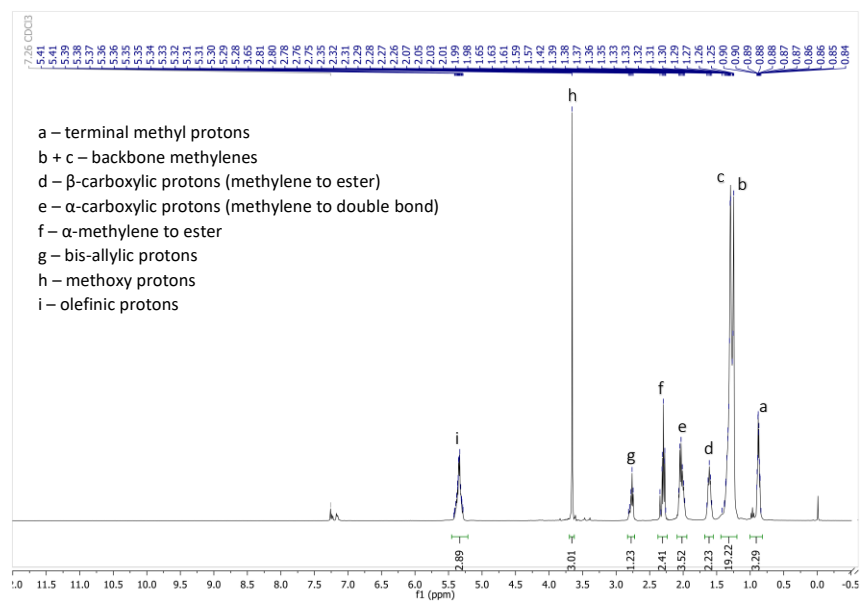


Figure S5. ^1H NMR Fatty acid methyl ester using $\text{SiO}_2\text{-SO}_3\text{H}$ as catalyst and $(\text{Bu}_4\text{N})(\text{BF}_4)$ as co-catalyst as co-catalyst.

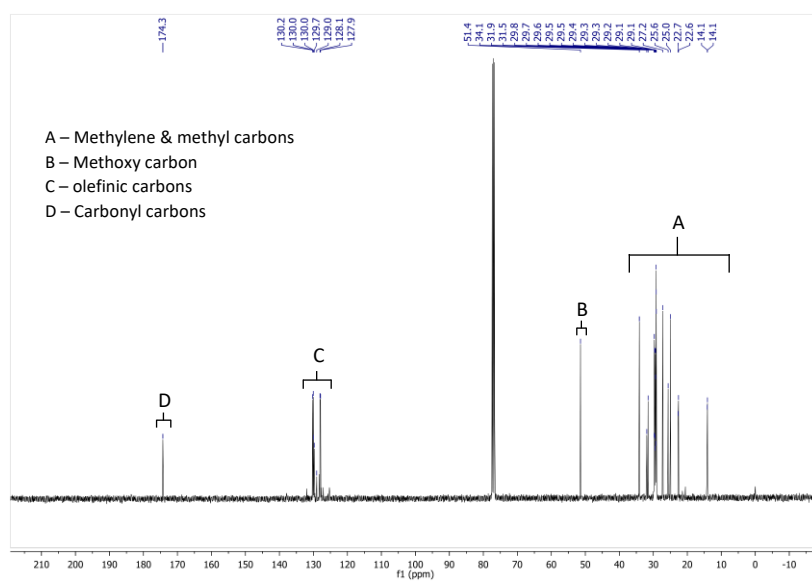


Figure S6. ^{13}C NMR Fatty acid methyl ester using $\text{SiO}_2\text{-SO}_3\text{H}$ as catalyst and $(\text{Bu}_4\text{N})(\text{BF}_4)$ as co-catalyst.

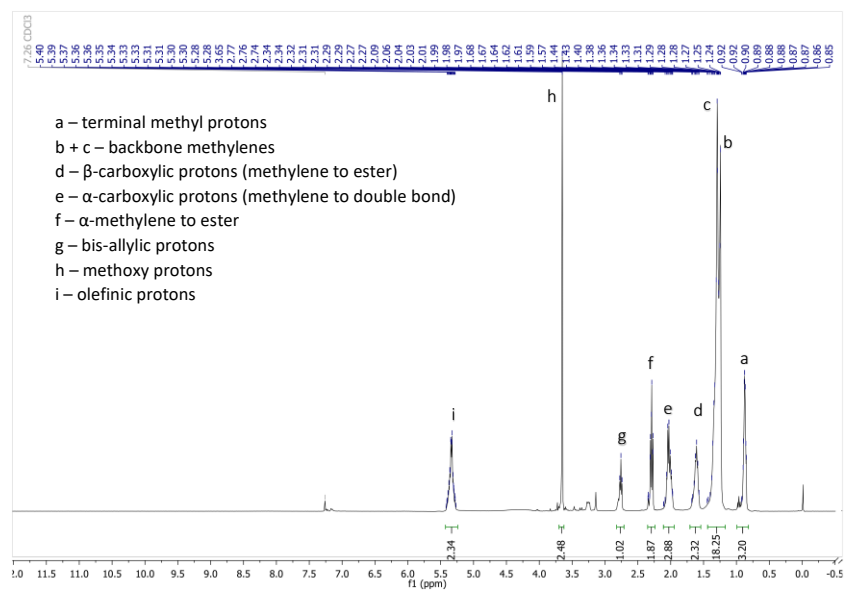


Figure S7. ^1H NMR Fatty acid methyl ester using $\text{SiO}_2\text{-SO}_3\text{H}$ as catalyst and Aliquat as co-catalyst.

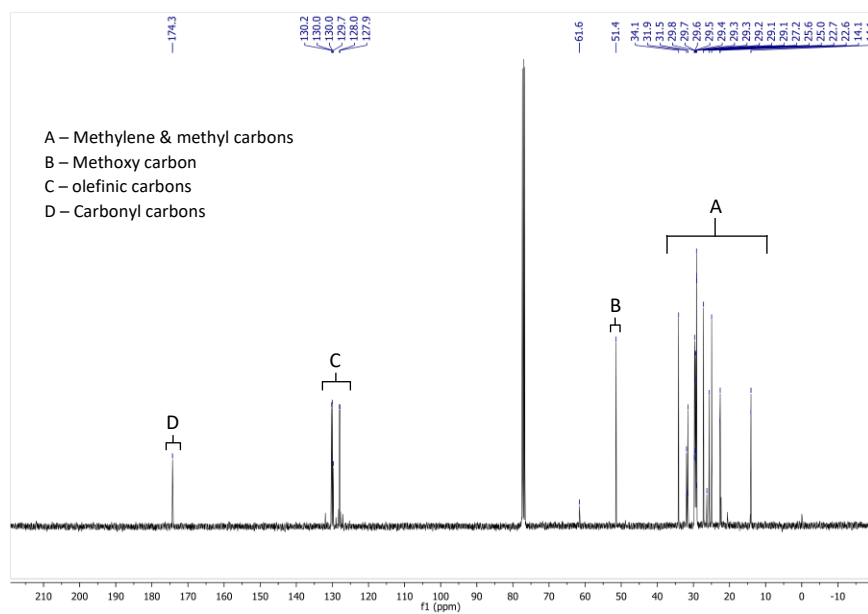


Figure S8. ^{13}C NMR Fatty acid methyl ester using $\text{SiO}_2\text{-SO}_3\text{H}$ as catalyst and Aliquat as co-catalyst.