Tailoring olefin distribution via tuning rare earth metals in bifunctional Cu-RE/beta-zeolite catalysts for ethanol upgrading

Background

- Bioethanol to middle distillate technologies have offered a unique solution to produce renewable aviation fuel for decarbonizing the hard-to-electrify sectors.
- Direct and selective production of C_{3+} alkene from bioethanol remains a critical challenge and important to produce renewable transportation fuels such as aviation biofuels.

Approach

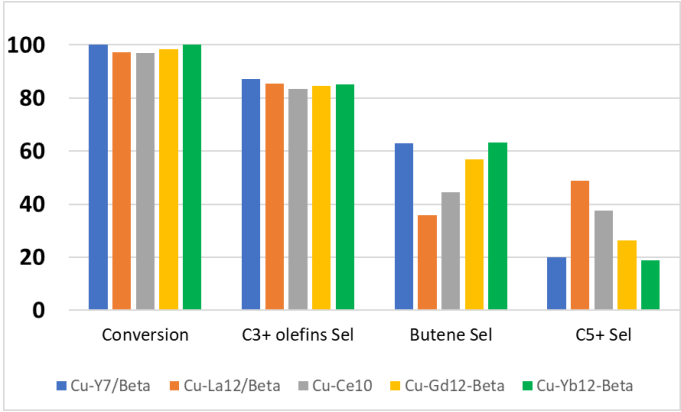
- The bimetallic Cu- and rare earth (RE)-doped DeAl-Beta zeolites (Cu-RE/Beta) catalysts were synthesized via solid state grinding
- Home-made microflow reactor was used to perform ethanol upgrading reaction and kinetic reaction rate measurement experiments
- Products were separated and analyzed using a gas chromatography

Results

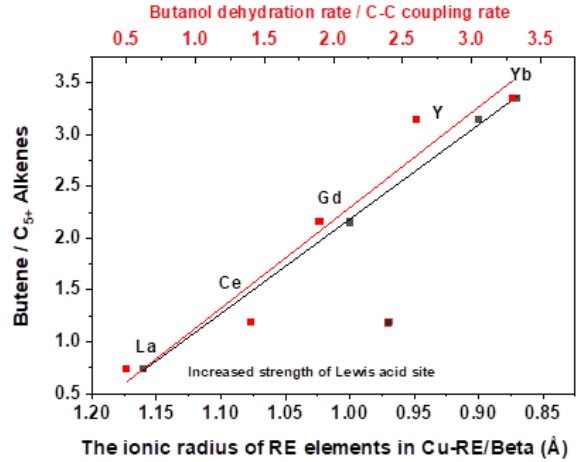
- Developed a series of Cu-RE/Beta catalysts that yield high C_{3+} alkene selectivity from ethanol upgrading (>80% selectivity at ~100% conversion, 623K)
- The formation rates of butene isomers to C_{5+} alkenes are linearly correlated with the strength of Lewis acidic RE identity, which follows the sequence of Yb_{12}/Beta >Y_7/Beta > Gd_{12}/Beta > Ce_{10}/Beta > La_{12}/Beta
- RE selection plays the vital role in altering the rate of the key competitive reactions within the ethanol-to-alkenes reaction network, namely C_4 alcohol dehydration and C-C chain growth, which dictate alkene product distributions

Significance

- This work provides a feasible and promising method for tailoring alkene product distributions from ethanol upgrading, which is of notable significance to the generation of renewable fuels.



Ethanol conversions and olefin product selectivities over bimetallic Cu-RE/Beta



The relative ratio of butene to C_{5+} olefin as a function of the ionic radius of RE metals, simultaneously in line with the fraction of the initial rate of butanol dehydration to C-C coupling

Li, M.J., Davison, B. & Sutton, A.D. et al., *Applied catalysis B: Envir. & Energy 344 (2024) 123648.* *doi.org/10.1016/j.apcatb.2023.123648*