



HIGHLY ACTIVE LEWIS ACIDIC ALUMINUM IONS FOR PROPYLENE OLIGOMERIZATION

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Research Topic

- The research topic was finding a catalyst that could propene oligomerization using Lewis acid sites.
- The purpose for this experiment was to find a better working catalyst to use for the fuel industry to make hydrocarbon chains.
- The question was: Can a catalyst made from alumina silica have the same conversion rates as a zeolite and will it contain only Lewis acid sites?
- It is hypothesized tetrahedral aluminum ions on amorphous silica will form Lewis acid sites similar to ones found in zeolites and be active for hydrocarbon reactions.

Experimental Design – Making a Catalyst

1. Decide the ratio of aluminum to put on the silica for a number of samples. The samples used ranged from 0.1 % aluminum to 1% aluminum.
2. Measure an equal mass of silica gel into 4 beakers and label them.
3. Prepare the Aluminum metal salt solutions by dissolving different amount of Aluminum nitrate into water to make different concentrated solutions for each percentage listed in step one.
4. Add drops of the aluminum solution onto the silica samples using a pipet and stir to evenly wet the silica it then repeat this step till the silica is saturated.
5. Place each sample into a drying oven after each time step 4 is completed then repeat step 4 until all of the solution is used.
6. Once the solution is gone, let the catalyst dry in a hot oven for several hours.
7. After it is drying, calcine the catalyst at 550C for three hours and once the oven is cooled down take out the catalyst.

Materials

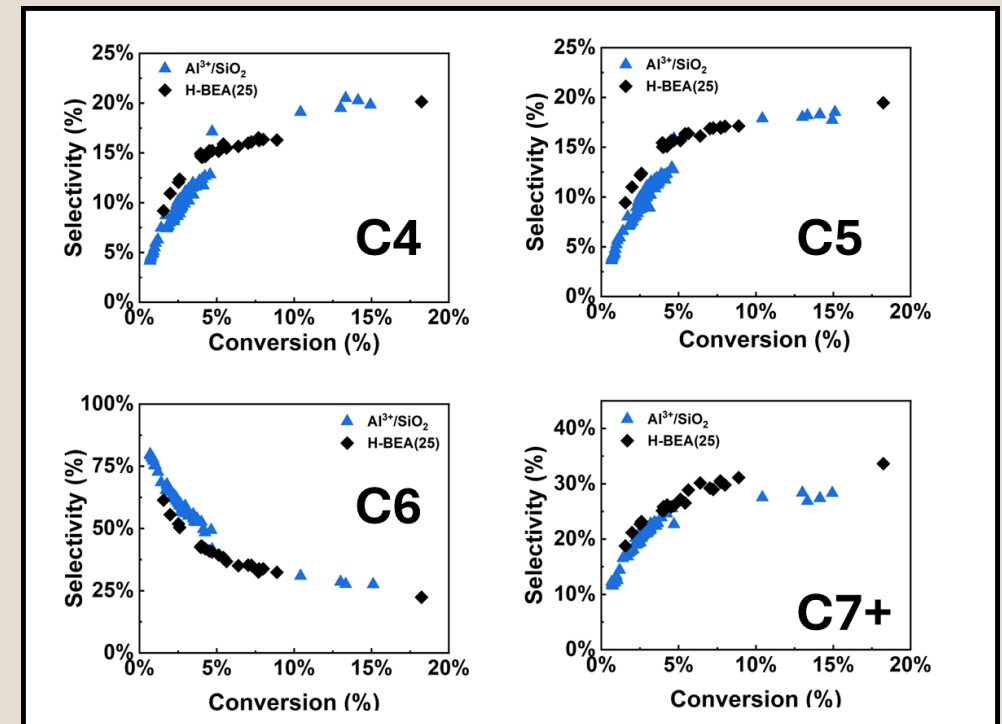
- Silica gel
- Aluminum nitrate nonahydrate (Al (NO₃)₃ 9H₂O)
- Distilled or deionized water
- Quartz wool
- Beakers
- Graduated cylinders
- Nitric acid
- Stirring rods
- Balance
- Filter paper and funnel
- Gas chromatograph

Experimental Design – Testing the Catalysts

1. Have a set up with a reactor attached to a gas chromatograph so that gas goes through the reactor into the gas Chromatograph.
2. Load the catalyst in a reactor.
3. The reactor will then be raised to a high temperature.
4. After desired temperature is reached send a gas mixture through the reactor and test what type of gases come out based on the data found by the gas chromatograph.

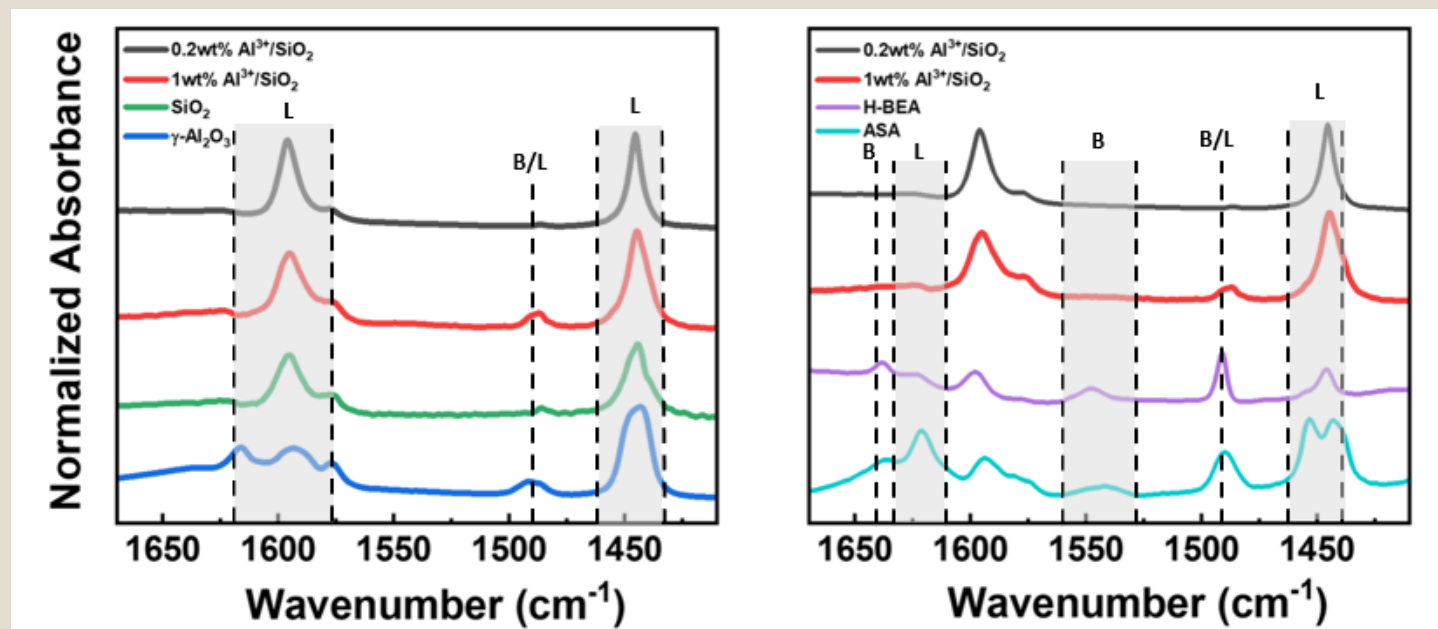
Data/Results

- These graphs show that the catalyst made $\text{Al}^{3+}/\text{SiO}_2$ produces the same products at similar conversion rates of that of the zeolite H-BEA.



Data/Results

- These two graphs show that the tested catalysts the black and red lines have Lewis acid sites. The other two lines represent zeolites which have both Bronsted acid sites as well as Lewis acid sites. This also shows the Lewis acid sites on the catalysts made are very similar to the Lewis acid sites on zeolites and the catalyst only contains Lewis acid sites.



Data Analysis

- Data gained from Infrared Spectroscopy found that the catalyst contained Lewis active sites with an absence of Bronsted active sites.
- During the experiment when propene was oligomerized it was able to make C4, C5, C6, and C7+ molecules. The conversion rate from these oligomerizations closely resembled that of a zeolite.
- Using magic angle spin nuclear magnetic resonance, it was found that structurally aluminum ions are tetrahedral.

Conclusions

- The data showed that this catalyst was able to do high conversions rates for propene oligomerization and the conversions rates were similar to zeolites.
- It was also found that the acid sites were only Lewis acid sites and this sites compared to the Lewis acid sites on zeolites.
- This data showed that catalyst made can preform reactions to make hydrocarbon chains at a very similar rate to that of a zeolite.
- The data supported the hypothesis. The catalyst made form aluminum was able to do high conversion rates similar to zeolites as well as it contained only Lewis acid sites as it was hypothesized.

Conclusions

- To improve this experiment for the future or to build upon the experimentation done here could be used to create actual gasoline.
- Another way it could be expanded upon is this method has been proven to be successful with creating smaller hydrocarbons so the next step could be larger to make larger hydrocarbons chains.
- This research is important due to the impact it has on fuel production. Fuel is currently creates toxic byproducts and it consumes a lot of energy. This could be solved with olefin oligomerization. If scientists are able to find a reliable way to make fuel based of the chemistry done here it will save energy to make fuel and cause less pollution.

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