



"Synthesis and resolution of a substituted dioxolane from glycerol"

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Abstract

Glycerol is one of the byproducts in the production of biofuels and there is a growing interest in the potential of glycerol as a chemical feedstock. Glycerol can undergo preferential 1,2 cyclic acetal formation with benzophenone under solvent free conditions in the presence of catalytic $\text{In}(\text{OTf})_3$ and stoichiometric orthoformate to form a racemic 2,2 substituted dioxolane. Conversion of the unreacted primary alcohol to an ester can be accomplished through reaction with a resolved chiral carboxylic acid or acid chloride. Resolution of the esters yields diastereomerically pure material in two steps from the glycerol starting material.

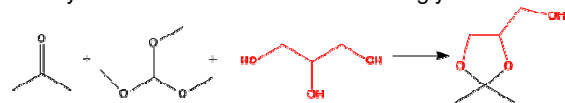


Introduction

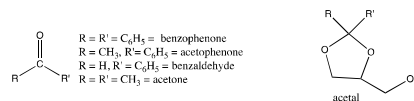
A chemical feedstock can be described as a minimally processed material that is used to synthesize other chemicals. Ideal chemical feedstocks are cheap, plentiful, renewable and safe. Glycerol is a byproduct in the production of renewable biodiesel.

Triglycerides produced by plants are utilized as starting materials in the creation of biodiesels. This means that a triglyceride is used in the manufacturing of another, usually more useful substance—in this case biodiesel. The long fatty acids chains cleaved from the original triglyceride are used as fuel, but the glycerol backbone is also left after the reaction concludes.

Glycerol is currently used in many commercially available products but not widely used as a chemical feedstock. We are looking for methods to utilize glycerol as a starting point for other organic compounds. In particular, this research investigates the synthesis of a chiral materials from glycerol.

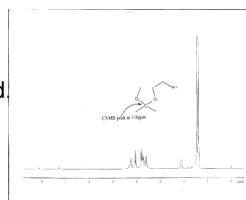


Methods



In a report in 2012, neat glycerol was reacted with a series of aromatic ketones in the presence of stoichiometric trimethylorthoformate and a catalytic amount of indium triflate.¹ In a similar manner, we have synthesized the acetal of glycerol and acetone.

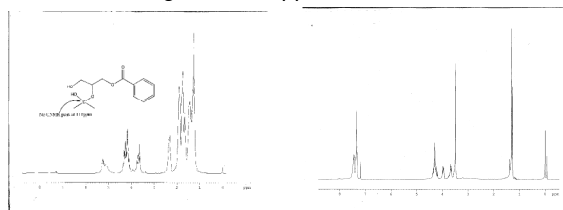
- Percent yield 70 to 80 percent yield.
- Only the 1,2 addition product is observed.
- Reaction done in neat glycerol.
- In CNMR, carbon 2 of the acetal is observed at 110 ppm – very distinctive.



Reaction of glycerol with benzophenone did not proceed to completion and reaction with acetophenone yielded two acetal products.

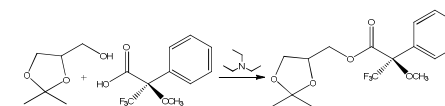
The number four carbon of the acetal is chiral. In order to form diastereomers of the acetal, we chose to esterify the remaining alcohol. Initial reactions were attempted with acid halides or carboxylic acids without external base. These conditions caused the acetal ring to open and effectively reverse the formation of the acetal.

- In HNMR the two unique methyl groups are lost.
- In CNMR, carbon signal at 110 ppm is lost.



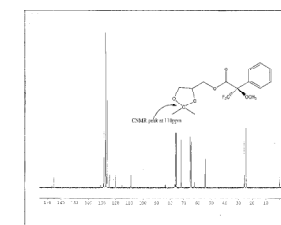
Reaction of simple acid chlorides (benzoyl chloride, or acetyl chloride) was accomplished in the presence of two equivalents of triethylamine in dichloromethane. The methodology with then applied to the acid chloride of Mosher's acid (formula). A single enantiomer of the acid chloride was used which should result in the formation of two diastereomers of the acetal ester.

Methods Continued



Surprisingly, HNMR and CNMR data of the acetal ester product showed the formation of a single product.

- Two unique methyl groups are present.
- In CNMR, signal at 110 ppm is present.



Future Work

- Optimize methods for reactions and isolation procedures to improve yields.
- Experiment with chirality of the ester produced from the reaction with Mosher's Acid and
- Find other ways to elaborate the acetal formed from glycerol.
- Continue to try and develop reactions that take into consideration the safety of the materials used and the amount of waste produced.

The use of glycerol as a chemical feedstock would allow biofuels to be an even greener renewable fuel source. I plan on continuing my research into the fall semester.

References

- Graham, Andrew E., Tomasz M. Kubczyk, and Brendan M. Smith. "Metal triflate catalyzed acetal exchange reactions of glycerol under solvent-free conditions." *RSC Advances*. The Royal Society of Chemistry, 21 Feb. 2012: 2702-2706. Web. 13 July 2012.
- March, Jerry, and Michael B. Smith. "10-112 Direct Conversion of Alkyl Halides to Aldehydes and Ketones." *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*. 5th ed. United States of America: John Wiley & Sons, Inc, 2001. 562-564. Print.
- Ciriminna, Rosaria, Cristina Della Pina, Hiroshi Kimura, Mario Pagliaro, and Michele Rossi. "From Glycerol to Value-Added Products." *Angewandte Chemie, Wiley Interscience*, 2007: 4434-4440. Web. July 2012.
- "Biodiesel." *Wikipedia, The Free Encyclopedia*. Wikimedia Foundation, Inc. 17 Jan. 2013. Web. 18 Jan. 2015.

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