Title – The Development of a Nucleophilic Substitution Reaction Experiment for the Organic Chemistry Laboratory

Program of Study – Chemistry (Department of Biology & Chemistry)

Presentation Type – Choose one of the following: Print Poster

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Abstract: The aim of this research is to develop a multifaceted organic chemistry I laboratory experiment for the nucleophilic substitution (S_N) reaction different from the currently available set of published experiments. The nucleophilic substitution reaction is a simple organic reaction of an electron pair donor, or the nucleophile, with an electron pair acceptor, whose leaving group is replaced, i.e. substituted, by the nucleophile. Nucleophilic substitution reactions are some of the first reactions taught in organic chemistry and lay the groundwork for further, more complicated reactions and mechanisms learned in subsequent chapters. They are pertinent not only to the field of chemistry, but to biology and biomedical sciences as well, as substitution reactions are present in many biological processes. Such processes include the biosynthetic transformation of norepinephrine to epinephrine; “Nitrogen mustard” anticancer drugs are believed to alkylate DNA using two substitution reactions; substitution reactions also occur in the biological conversion of geranyl diphosphate to geraniol, a pungent alcohol found in roses and perfumes; the hydrolytic breakdown of carbohydrates also occurs through substitution reactions, allowing humans to break down carbohydrates in bread and pasta. Thus, a good understanding of substitution reactions are necessary not only for understanding chemistry, but also for a comprehensive understanding of many biological processes. Given the importance of S_N reactions, most colleges incorporate a S_N reaction experiment in their organic chemistry laboratories. Examples include the reaction of phenoxides, ethanolic silver nitrate, sodium iodide
salts, hydrosulfides, and phosphorous nucleophiles with alkyl halides. While these are all examples that correctly teach S_N reactions, many of them are isolated, one-lab period experiments with no or little integration into the overall sequence of the course laboratory experiments. We thus aim at designing an experiment that is part of a larger laboratory sequence, making it easier for the students to follow that compound over several laboratory experiments. Using this approach will also be more economic, as students can use the compound they made in the previous lab as a reactant in their next lab, rather than disposing the S_N product as waste and using an entirely different compound for the subsequent experiment. In addition, the majority of all presently employed S_N experiments use but one single observation to analyze the success of the S_N reaction, such as visual observation. We desire to find a reaction where multiple analytical tools can be employed to see if a reaction occurred, such as melting point, thin-layer chromatography (TLC), and infra-red spectroscopy (IR). This will allow students to not only get more than a visual observation, but to learn how to perform basic analyses of compounds using a variety of techniques. In addition, the reaction must occur within two and a half hours so that it can be run in a single lab period. To identify a SN reaction that will meet all the above-mentioned requirements, we will be trying different combinations of solvents, nucleophiles and reaction conditions.

**Christian worldview integration:** Research correlates strongly with a Christian worldview. Romans 1:20 says, “For since the creation of the world God’s invisible qualities—his eternal power and divine nature—have been clearly seen, being understood from what has been made, so that men are without excuse.” This, as well as many other verses, tells us that God is revealed in what He has made. God is revealed in the way that the human hand works, in the way artists can create art, and in the way that S_N reactions are done. My Christian worldview has made me
look at this research as an opportunity to learn more about God. God is so vast and great that no one could ever fully know Him, but every new thing we discover reveals a little more of His greatness and reminds us of how worthy He is of being praised. Our research can also help us show others how great God is. I also believe that God delights in education. Proverbs 18:15 says that “the ear of the wise seeks knowledge”. God gave us the ability to perform research, to teach, and to gain knowledge. Proverbs 1:5 says, “Let the wise hear and increase in learning”. God wants us to increase in learning and to discover more of the general revelation that He gives us. Developing an organic laboratory experiment allow us to do that. Not only does this research allow us to learn more about God and who He is, but it also lets us teach it to others in a practical, hands-on way.