Green chemistry in undergraduate education: Organocatalysis in practical laboratory classes

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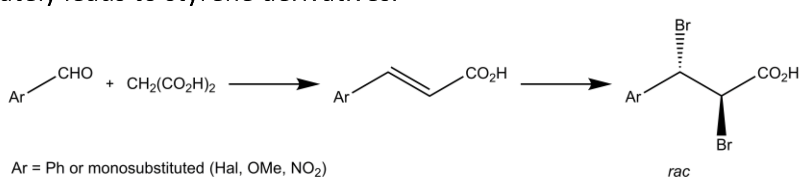
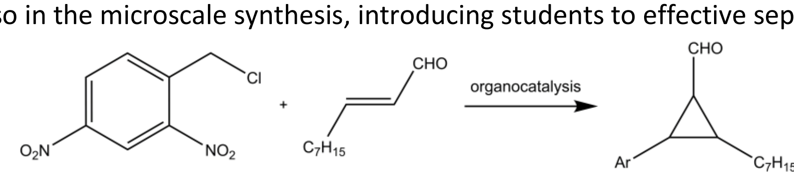
The 12 principles of green chemistry highlight a pursuit that leads to environmentally friendly, safer and more sustainable processes and products, ideally in as small a number of steps as possible and generating no or little waste while using small amounts of energy and other resources. These desirable syntheses have also inspired chemistry education and outreach due to an increased awareness of chemistry's role in solving future problems.

The University of Southampton maintains a sustainability agenda and the chemistry department has lecture courses introducing undergraduate students to how chemistry can contribute to environmental topics. Consequently, the laboratory classes have embraced green chemistry in their practical education. In this presentation practicals from our undergraduate synthesis teaching laboratory that have an ecological background and are implicitly linked to green chemistry will be highlighted.

One example is a three step synthesis of styrene derivatives that starts with a Knövenagel-Döbner condensation to form cinnamic acid derivatives. This step can be carried out in the traditional way using piperidine and pyridine, or using more benign solvents and bases together with an organocatalyst. In the second step the bromination of the double bond can be performed directly with bromine or safer substitutes. Again, the impact of the choice of reagent is evaluated by the students on the basis of the 12 principles of green chemistry. In the last step the choice of solvent has an influence on the stereochemical outcome of the elimination that ultimately leads to styrene derivatives.



Another example from our advanced practical classes is the use of proline derivatives in the synthesis of trisubstituted cyclopropanones. This organocatalytic reaction avoids transition metals and the versatile one-pot synthesis of a highly functionalised product is discussed with environmental credentials in mind. The latter aspect plays a role also in the microscale synthesis, introducing students to effective separation techniques.



Variations in these organocatalytic syntheses as well as the educational setting (traditional versus research-inspired problem-based learning) will be discussed together with the green chemistry aspects of these practicals which have been successfully implemented for several years.

In conclusion, green chemistry has a strong, early presence in our chemistry education. This presentation will highlight experiments with an organocatalysis background that have successfully enticed students to the importance that thinking beyond a simple yield holds in finding more sustainable processes.