What is Green Chemistry?

Through green chemistry we aim to develop cleaner, safer, and more efficient reactions by carefully analysing our experimental processes. The concepts of green chemistry are captured in the 12 Principles of Green Chemistry:

1. Aim to **minimise waste** at every step. Make prevention of waste a top priority.
2. Consider **atom economy** when choosing synthetic steps. In high atom economy processes, the stoichiometry of the reaction ensures that few “atoms” are wasted – at the extreme, all atoms from the reagents appear in the products.
3. Consider using **less hazardous chemical reagents** to minimize impact to human health and environment.
4. Try to **predict the environmental fate** of your molecules and consider designing molecules to minimise the potential harm. For example, polyfluorinated alkanes are persistent pollutants.
5. Aim to **reduce solvent quantities** where possible, and to use the safest possible solvents. For example, if it is safe to do so, you might be able to substitute DMF or NMP with Cyrene for reactions, or CH_2Cl_2 with tert-butyl methyl ether for chromatography.
6. Aim to use **low-energy processes**; room temperature is “greener” than low temperature or high temperature.
7. Consider using chemicals which are, or can be, derived from **bio-renewable feedstocks**. Even if you do not use bio-renewable chemicals yourself, if your work is scaled up then this design consideration provides a valuable opportunity for those who use your work.
8. Where possible, **avoid isolating derivatives** if not necessary. For example, can you *telescope* several synthetic steps, avoiding environmentally costly purification steps? Can you use more regioselective reactions which might reduce the need for protecting groups?
9. Explore opportunities to **use catalytic reactions**, which might remove the need for stoichiometric reagents and so reduce waste.
10. Consider designing **biodegradable materials**. For example, you might be able to introduce biologically cleavable groups into a polymer synthesis.
11. **Monitor your reactions carefully**, to identify when and if pollutants are generated, and to act to prevent release to the environment when safe.
12. **Always have safety as your foremost consideration**. Design your processes to avoid hazards from the outset, and carefully risk assess all experiments.

For more information on Green Chemistry options, please visit the following website:

- Sigma Aldrich Greener Alternatives
- ACS Solvent Selection Tool
- OSHA - Transitioning to Safer Chemicals
- Michigan Green Chemistry Clearinghouse