



# Green chemistry

Green chemistry is sustainable chemistry, and it's all about doing what's right for the environment!

Green chemistry, or sustainable chemistry, is a concept that can be used effectively throughout all areas of chemistry. The idea is that scientists should perform their experiments and research in more environmentally friendly ways, by developing practices such as minimising and re-using wastes, being more energy and resource-efficient and monitoring procedures carefully. This philosophy has become integrated into chemical practices more widely as we become more aware of global warming and other environmental issues, and can be economically advantageous to businesses too.

These principles can be applied to any area of chemistry. Green chemistry is not a field of chemistry that can be used independently: it is a way of doing all chemistry.



Image credit: Paul Ricketts

The 12 principles of green chemistry:

1. **Prevent waste** – find and use chemical reactions that don't make by-products that need to be thrown away.
2. **Design safer chemicals and products** – make chemicals that aren't poisonous or environmentally harmful.
3. **Design less hazardous chemical syntheses** – find ways of making chemicals that aren't as dangerous to humans or the environment.
4. **Use renewable feedstocks** – use starting reagents that are easily replaceable, like plants or wastes from other processes rather than fossil fuels or minerals.
5. **Use catalysts, not stoichiometric reagents** – use small amounts of a catalyst to make a reaction happen, rather than putting lots of different chemicals together in large amounts.
6. **Avoid chemical derivatisation** – don't make derivatives (compounds that are very similar in structure to the parent compound) in order to carry a transformation. More chemicals are needed to change them into the desired substance.
7. **Maximise atom economy** – make sure that as many of the atoms in the starting reagents are actually in the finished product, rather than having lots of waste by-products.
8. **Use safer solvents and reaction conditions** – don't use harmful solvents: this may mean doing the reaction a different way or finding a safer solvent to use.
9. **Increase energy efficiency** – do reactions at room temperature.
10. **Design chemicals and products to degrade after use** – make substances that are biodegradable.
11. **Analyse in real time to prevent pollution** – monitor and control reactions as they happen so that by-products can be minimised.
12. **Minimise the potential for accidents** – don't use chemicals that are likely to explode, cause fires or lead to harmful emissions.

At UWA, Dr Mohamed Makha and his team have applied these green chemistry principles to find a new, environmentally friendly way to extract chitin from lobster shells. Chitin is a very useful polymer that can be used to produce a number of pharmaceuticals, such as glucosamine for arthritis sufferers and anti-bacterial gels used to treat soldiers' wounds in Iraq. Dr Makha's method of extracting chitin from lobsters is completely new and exemplifies green chemistry principles.

The lobster shells that Dr Makha extracts the chitin from are usually discarded by the fisheries industry and become landfill, so using them reduces wastes and saves money. Dr Makha has also produced a new environmentally friendly solvent for his technique, replacing hydrochloric acid, which is corrosive and environmentally hazardous. The new green solvent is made from biomass so it utilises a renewable resource and is cheap. In addition, Dr Makha has found that he can use a microwave as an energy source for the extraction reaction. This has the advantage of being easy to control, so more of the correct product can be made, as well as being less wasteful than current practices which use huge amounts of heating. Dr Makha believes that it is more ethical to use green chemistry practices and that scientists should be more environmentally aware.



Image credit: Paul Ricketts

**Dr Mohamed Makha**



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