**The 12 Principals of Green Chemistry**

Green chemistry is based upon the 12 basic principles, which are listed below. The principals listed below are as shown on the American Chemical Societies website[[1]](#endnote-1) and the more simplified version of the principal come from a lesson written by Beyond Benign4.

**The 12 Principles of Green Chemistry**

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| **Principal as described by the American Chemical Society** | **Principal in more simple terms2** |
| 1. **Prevention**   It is better to prevent waste than to treat or clean up waste after it has been created. | Create no waste |
| 1. **Atom Economy**   Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product. | Nothing should be left over |
| 1. **Less Hazardous Chemical Syntheses**   Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment. | No toxicity |
| 1. **Designing Safer Chemicals**   Chemical products should be designed to affect their desired function while minimizing their toxicity. | Green products have to work as well as non-green products |
| 1. **Safer Solvents and Auxiliaries**   The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used. | Get rid of all non-essential additives |

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| **Principal as described by the American Chemical Society** | **Principal in more simple terms2** |
| 1. **Design for Energy Efficiency**   Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure. | Reduce energy usage |
| 1. **Use of Renewable Feedstocks**   A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable. | Use renewable materials |
| 1. **Reduce Derivatives**   Unnecessary derivatization (use of blocking groups, protection/ deprotection, temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste. | Get rid of as many steps as possible |
| 1. **Catalysis**   Catalytic reagents (as selective as possible) are superior to stoichiometric reagents. | Make use of a reusable method to speed up a reaction |
| 1. **Design for Degradation**   Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment. | Use materials that break down in the environment (Biodegradable) |
| 1. **Real Time Analysis for Pollution Prevention**   Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances. | Check everything you do against the other principles |
| 1. **Inherently Safer Chemistry for Accident Prevention**   Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires. | Safety first |

1. <http://www.acs.org/content/acs/en/greenchemistry/about/principles/12-principles-of-green-chemistry.html> [↑](#endnote-ref-1)