

12 Principles of Green Chemistry*



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1 Waste Prevention



It is better to prevent waste than to treat or clean it up after it's been created.

2 Atom Economy



Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product

3 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.

4 Designing Safer Chemicals



Chemical products should be designed to affect their desired function while minimizing their toxicity.

5 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.

6 Design for Energy Efficiency



Energy requirements of chemical processes should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure.

7 Use of Renewable Feedstocks



A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.

8 Reduce Derivatives



Unnecessary derivatization (use of blocking groups, protection/ deprotection, temporary modification of physical/chemical processes) should be minimized or avoided if possible. Such steps require additional reagents and can generate waste.

9 Catalysis



Catalytic reagents (as selective as possible) should be used in place of stoichiometric reagents.

10 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.

11 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.

12 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

For more information, visit: [Beyond Benign](#)



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*Anastas, Paul T., and John Charles Warner. Green Chemistry: Theory and Practice. Oxford University Press, 1998