# APPENDIX 2–4

## APPENDIX 2: Criteria for Classifying Hazards of Chemicals

The criteria are based on the Globally Harmonized System of Classification and Labelling of Chemicals (GHS), regulation (EC) No 1272/2008.

|  |  |
| --- | --- |
| **Physical hazard statement** | **Score (S)** |
| H200 | 3 |
| H201 | 3 |
| H202 | 3 |
| H203 | 3 |
| H204 | 2 |
| H205 | 3 |
| H206 | 3 |
| H207 | 3 |
| H208 | 3 |
| H220 | 3 |
| H221 | 2 |
| H222 | 3 |
| H223 | 2 |
| H224 | 3 |
| H225 | 3 |
| H226 | 2 |
| H227 | 2 |
| H228 (category 1) | 3 |
| H228 (category 2) | 2 |
| H229 | 2 |
| H230 | 3 |
| H231 | 2 |
| H232 | 3 |
| H240 | 3 |
| H241 | 3 |
| H242 (type C & D) | 3 |
| H242 (type E & F) | 2 |
| H250 | 3 |
| H251 | 3 |
| H252 | 2 |
| H260 | 3 |
| H261 (category 2) | 3 |
| H261 (category 3) | 2 |
| H270 | 3 |
| H271 | 3 |
| H272 (category 2) | 3 |
| H272 (category 3) | 2 |
| H280 | 2 |
| H281 | 2 |
| H290 | 2 |
| EUH001 | 3 |
| EUH006 | 3 |
| EUH014 | 3 |
| EUH018 | 3 |
| EUH019 | 3 |
| EUH044 | 3 |
| EUH209 | 3 |
| EUH209A | 2 |

|  |  |
| --- | --- |
| **Health hazard statement** | **Score (S)** |
| H300 | 3 |
| H301 | 3 |
| H302 | 2 |
| H303 | 2 |
| H304 | 3 |
| H305 | 2 |
| H310 | 3 |
| H311 | 3 |
| H312 | 2 |
| H313 | 2 |
| H314 | 3 |
| H315 | 2 |
| H316 | 2 |
| H317 | 2 |
| H318 | 3 |
| H319 | 2 |
| H320 | 2 |
| H330 | 3 |
| H331 | 3 |
| H332 | 2 |
| H333 | 2 |
| H334 | 3 |
| H335 | 2 |
| H336 | 2 |
| H340 | 3 |
| H341 | 3 |
| H350 | 3 |
| H351 | 3 |
| H360 | 3 |
| H361 | 3 |
| H362 | 2 |
| H370 | 3 |
| H371 | 3 |
| H372 | 3 |
| H373 | 3 |
| EUH029 | 3 |
| EUH031 | 3 |
| EUH032 | 3 |
| EUH066 | 2 |
| EUH070 | 3 |
| EUH071 | 3 |
| EUH201 | 3 |
| EUH201A | 2 |
| EUH202 | 3 |
| EUH203 | 2 |
| EUH204 | 2 |
| EUH205 | 2 |
| EUH206 | 3 |
| EUH207 | 3 |
| EUH208 | 2 |

|  |  |
| --- | --- |
| **Environmental hazard statement** | **Score (S)** |
| H400 | 3 |
| H401 | 3 |
| H402 | 2 |
| H410 | 3 |
| H411 | 3 |
| H412 | 2 |
| H413 | 2 |
| H420 | 3 |
| EUH059 | 3 |

## Appendix 3: Criteria to Classify Substances Regarding Degradability and Renewability

|  |  |  |
| --- | --- | --- |
| **Characteristics** | **Criteria** | **Score (S)** |
| Degradability | Not degradable and may not be treated to render the substances degradable to innocuous products | 3 |
| Not degradable but may be treated to render the substances degradable to innocuous products | 2 |
| Degradable and breakable to innocuous products | 1 |
| Renewability | Not renewable | 3 |
| Renewable | 1 |

## APPENDIX 4: Green Chemistry Principles and Assessment Criteria for Value of Perceived Greenness

The value of perceived greenness (V) ranges from 1 (lowest level of perceived greenness) to 3 (highest level of perceived greenness).

| **Descriptions** | **Assessment criteria for the value of perceived greenness (V)** | |
| --- | --- | --- |
| **P1 – prevention**  It is better to prevent waste than to treat or clean up waste after it has been created. | 3 | Waste is innocuous (S = 1, appendix 2) |
| 2 | Waste involves a moderate hazard to human health and environment (S = 2, appendix 2, for at least one substance, no substances with S = 3) |
| 1 | Waste involves a high hazard to human health and environment (S = 3, appendix 2, for at least one substance) |
| **P2 – atom economy**  Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product. | 3 | Reactions without excess of reagents (≤ 10 %) and without formation of by-products |
| 2 | Reactions without excess of reagents (≤ 10 %) and with formation of by-products |
| 2 | Reactions with excess of reagents (> 10 %) and without formation of by-products |
| 1 | Reactions with excess of reagents (> 10 %) and with formation of by-products |
| **P3 – less hazardous chemical synthesis**  Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment. | 3 | All substances involved are innocuous (S = 1, appendix 2) |
| 2 | Substances involved with moderate hazard to human health and environment (S = 2, appendix 2, for at least one substance, no substances with S = 3) |
| 1 | Substances involved with high hazard to human health and environment (S = 3, appendix 2, for at least one substance) |
| **P4 – designing safer chemicals**  Chemical products should be designed to affect their desired function while minimizing their toxicity. | | |
| **P5 – safer solvents and auxiliary substances**  The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used. | 3 | Solvents and auxiliary substances are not used, but if used are innocuous (S = 1, appendix 2) |
| 2 | Solvents or/and auxiliary substances are used with moderate hazard to human health and environment (S = 2, appendix 2, for at least one substance, no substances with S = 3) |
| 1 | Solvents or/and auxiliary substances are used with high hazard to human health and environment (S = 3, appendix 2, for at least one substance) |
| **P6 – increase energy efficiency**  Energy requirements of chemical processes should be recognized for their environmental and economic impacts should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure. | 3 | Room temperature and pressure |
| 2 | Room pressure and temperature between 0 and 100 ºC when cooling or heating is needed |
| 1 | Pressure different from room pressure and/or temperature > 100 ºC or less than 0 ºC |
| **P7 – use renewable feedstocks**  A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable. | 3 | All raw materials/feedstocks are renewable (S = 1, appendix 3) |
| 2 | At least one raw material/feedstock is renewable, water is not considered (S = 1, appendix 3) |
| 1 | None of the raw materials/feedstocks are renewable, water is not considered S = 3, appendix 3) |
| **P8 – reduce derivatives**  Unnecessary derivatization (use of blocking groups, protection/deprotection, and temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste. | 3 | Derivatizations are not used or with one stage |
| 2 | Only one derivatization or with two stages |
| 1 | More than one derivatization or more than two stages |
| **P9 – catalysts**  Catalytic reagents (as selective as possible) are superior to stoichiometric reagents. | 3 | Innocuous catalysts are used (S = 1, appendix 2) |
| 2 | Catalysts are used with moderate hazard to human health and environment (S = 2, appendix 2) |
| 1 | Catalysts are used with high hazard to human health and environment (S = 3, appendix 2) or catalysts are not used |
| **P10 – 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. | 3 | All substances involved are degradable and break down to innocuous products (S = 1, appendix 3) |
| 2 | All substances involved not degradable may be treated to render them degradable to innocuous products (S = 2, appendix 3) |
| 1 | At least one substance is not degradable nor may be treated to render it degradable to innocuous products (S = 3, appendix 3) |
| **P11 – 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. | | |
| **P12 – 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. | 3 | Substances used with low hazard to cause chemical accidents (S = 1, appendix 2, considering health and physical hazards) |
| 2 | Substances used with moderate hazard to cause chemical accidents (S = 2, appendix 2, or at least one substance, considering health and physical hazards, no substances with S = 3) |
| 1 | Substances used with high hazard to cause chemical accidents (S = 3, appendix 2, for at least one substance, considering health and physical hazards) |

## References

Ribeiro, M. G. T., Costa, D. A., & Machado, A. A. (2010). “Green Star”: a holistic Green Chemistry metric for evaluation of teaching laboratory experiments. *Green Chemistry Letters and Reviews, 3*(2), 149-159. <https://doi.org/10.1080/17518251003623376>

Ribeiro, M. G. T., & Machado, A. A. (2014). Green star construction. <http://educa.fc.up.pt/documentosQV/EV/Construction%20of%20Green%20Star_6_points_GSAI.xlsx>