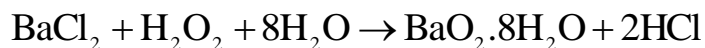


## Synthesis of barium peroxide – Protocol A



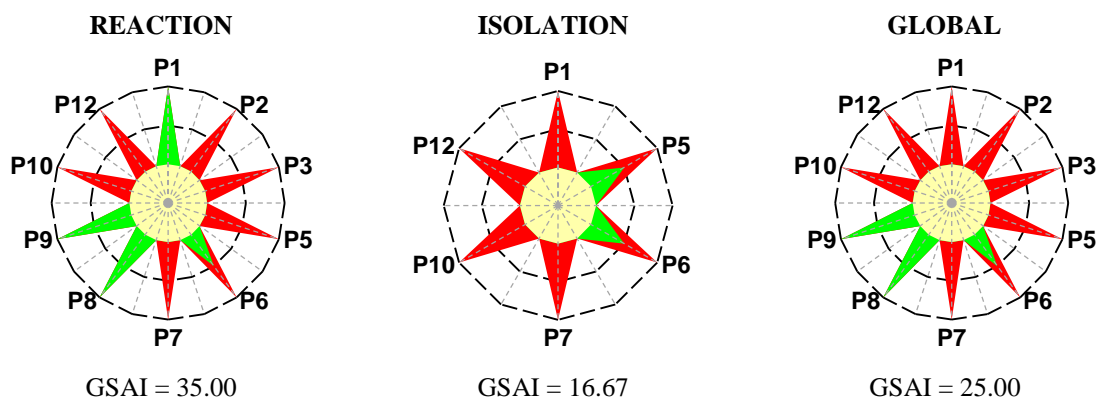
**Reaction.** In a flask, dissolve about 5 g (24.01 mmol) of barium chloride in 200 mL of distilled water. In a beaker, place 15 mL of 25% solution of ammonium hydroxide, 30 mL (53.57 mmol) of hydrogen peroxide solution 20 vol (about 123% excess) and cool in ice. Fit a funnel and add, dropwise and with stirring, the barium chloride solution. When the addition is complete, maintain the reaction mixture in ice for 20 to 30 minutes.

**Isolation.** Filter the crystals by suction, wash with cold distilled water, ethanol and ethyl ether and air dry.

**Purification.** Not prescribed.

**Safety.** See hazards associated with the reagents in Table 1.

**Greenness Assessment.** The evaluation was performed using the Green Star (GS) and the results are shown in Figure 1.



**Figure 1.** Greenness assessment (GS) for the synthesis of barium peroxide

## Construction of the GS

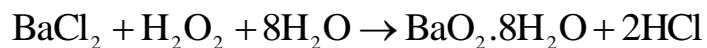


Table 1 presents the hazards and scores associated with the substances involved and Table 2 presents the scores used to construct the green stars.

**Table 1.** Hazards for the synthesis of barium peroxide, protocol A<sup>α</sup>

Substances involved	Step			Hazard code	Score: hazards to...		
	R	I	Pu		HH	E	P
<b>Stoichiometric reagents</b>							
Barium chloride (CAS 10361-37-2)	✓			H301, H332	3	1	1
Hydrogen peroxide (solution)	✓			H302, H318	3	1	1
<b>Auxiliary substances</b>							
<b>Solvents</b>							
Ammonium hydroxide (25% solution)	✓			H290, H314, H335, H400	3	3	2
Ethanol <sup>b</sup> (CAS 64-17-5)		✓		H225	1	1	3
Ethyl ether (CAS 60-29-7)		✓		H224, H302, H336, EUH019, EUH066	2	1	3
Water <sup>a,b</sup>	✓	✓		-	1	1	1
<b>Product</b>							
Barium peroxide (1304-29-6)	✓	✓		H272 (cat. 2), H302, H332	2	1	3
<b>Waste</b>							
Ammonium hydroxide (dilute solution)		✓		H315, H318, H400	3	3	1
Ethanol <sup>b</sup>		✓		H225	1	1	3
Ethyl ether		✓		H224, H302, H336, EUH019, EUH066	2	1	3
Hydrochloric acid (dilute solution)		✓		-	1	1	1
Hydrogen peroxide (dilute solution)		✓		-	1	1	1
Water <sup>a,b</sup>		✓		-	1	1	1

<sup>α</sup> R – Reaction; I – Isolation; Pu – Purification; HH – Human Health; E – Environment; P – Physical

<sup>a</sup> Renewable; <sup>b</sup> Degradable to innocuous products

**Table 2.** Scores used to construct the green star for the synthesis of barium peroxide, protocol A<sup>a</sup>

Green Chemistry Principle	Reaction		Isolation		Global	
	s	Explanation	s	Explanation	s	Explanation
<b>P1</b> Prevention	3	Without waste	1	Dilute ammonium hydroxide, H318 and H400	1	Dilute ammonium hydroxide, H318 and H400
<b>P2</b> Atom Economy	1	Excess of hydrogen peroxide > 10%, formation of by-products		NA	1	Excess of hydrogen peroxide > 10%, formation of by-products
<b>P3</b> Less hazardous chemical synthesis	1	Barium chloride, H301, hydrogen peroxide, H318, and ammonium hydroxide, H314 and H400		NA	1	Barium chloride, H301, hydrogen peroxide, H318, and ammonium hydroxide, H314 and H400
<b>P5</b> Safer solvents and auxiliary substances	1	Ammonium hydroxide, H314 and H400	2	Ethyl ether, H302, H336 and EUH066	1	Ammonium hydroxide, H314 and H400
<b>P6</b> Increase energy efficiency	2	0 °C ≤ T ≤ 100 °C	2	0 °C ≤ T ≤ 100 °C	2	0 °C ≤ T ≤ 100 °C
<b>P7</b> Use renewable feedstocks	1	Substances not renewable	1	Substances not renewable	1	Substances not renewable
<b>P8</b> Reduce derivatives	3	One stage		NA	3	One stage
<b>P9</b> Catalysts	3	Without catalysts		NA	3	Without catalysts
<b>P10</b> Design for degradation	1	Substances not degradable	1	Substances not degradable	1	Substances not degradable
<b>P12</b> Safer chemistry for accident prevention	1	Barium chloride, H301, hydrogen peroxide, H318, ammonium hydroxide, H314, and barium peroxide, H272 (cat.2)	1	Ethanol, H225, ethyl ether, H224, barium peroxide, H272 (cat.2), and ammonium hydroxide, H314	1	Barium chloride, H301, hydrogen peroxide, H318, ammonium hydroxide, H314, barium peroxide, H272 (cat.2), ethanol, H225, and ethyl ether, H224

<sup>a</sup>s – Score; NA – Not applicable

## References

Instituto Superior Técnico – Universidade Técnica de Lisboa, <https://fenix.ist.utl.pt/disciplinas/lq-i/2010-2011/1-semester> (accessed February 2011).