

Synthesis of 3-nitrobenzoic acid

Evaluation of protocols including a preliminary step of preparation of reagents

Protocol D¹

The greenness assessment made for protocol D did not include the preparation of reagents. If this step is considered to the greenness, the final evaluation corresponds to Figure 1. Table 1 presents the hazards and scores associated with the substances involved and Table 2 presents the scores used to construct the green stars.

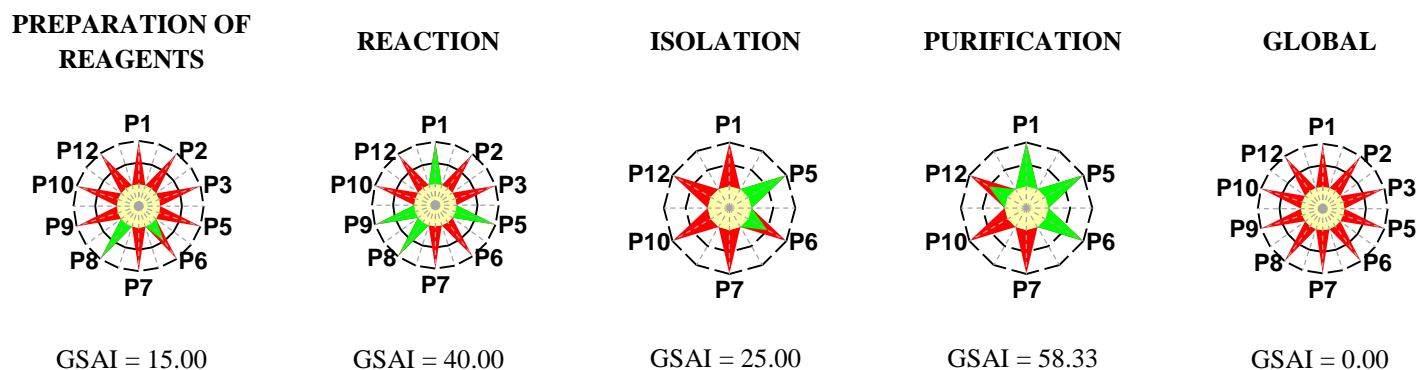


Figure 1. Greenness assessment (GS) for the synthesis of 3-nitrobenzoic acid, protocol D

Table 1. Hazards for the synthesis of 3-nitrobenzoic acid, protocol D^α

Substances involved	Step				Hazard code	Score: hazards to...		
	Prep	R	I	Pu		HH	E	P
Stoichiometric reagents								
Hydrochloric acid (CAS 7647-01-0)		✓			H314, H335	3	1	1
Methyl benzoate (CAS 93-58-3)	✓				H302	2	1	1
Methyl m-nitrobenzoate(CAS 618-95-1)		✓			-	1	1	1
Nitric acid (CAS 7697-37-2)	✓				H272 (cat. 3), H314	3	1	2
Sodium hydroxide (CAS 1310-73-2)		✓			H314	3	1	1
Auxiliary substances								
Solvents								
Hydrochloric acid (1% solution)				✓	-	1	1	1
Methanol (CAS 67-56-1)	✓				H225, H301, H311, H331, H370	3	1	3
Water ^{a,b}	✓	✓	✓		-	1	1	1
Other auxiliary substances								
Activated charcoal (CAS 7440-44-0)		✓			-	1	1	1
Sulphuric acid (CAS 7664-93-9)	✓				H314	3	1	1
Product								
3-nitrobenzoic acid (121-92-6)		✓	✓	✓	H302, H315, H319, H335, H412	2	2	1
Waste								
Hydrochloric acid (dilute solution)				✓	-	1	1	1
Methanol	✓		✓		H225, H301, H311, H331, H370	3	1	3
Nitric acid (dilute solution)	✓				-	1	1	1
Sodium chloride (aqueous solution)			✓		-	1	1	1
Sulphuric acid (dilute solution)	✓				-	1	1	1
Water ^{a,b}	✓		✓		-	1	1	1

^α Prep – Preparation of reagents; R – Reaction; I – Isolation; Pu – Purification; HH – Human Health; E – Environment; P – Physical

^a Renewable; ^b Degradable to innocuous products

Table 2. Scores used to construct the green star for the synthesis of 3-nitrobenzoic acid, protocol D^a

Green Chemistry Principle	Preparation of reagents		Reaction		Isolation		Purification		Global	
	s	Explanation	s	Explanation	s	Explanation	s	Explanation	s	Explanation
P1 Prevention	1	Methanol, H301, H311, H331, H370	3	Without waste	1	Methanol, H301, H311, H331, H370	3	Waste is innocuous	1	Methanol, H301, H311, H331, H370
P2 Atom Economy	1	Excess of nitric acid > 10%, formation of by-products	1	Excess of sodium hydroxide and of hydrochloric acid > 10%, formation of by-products		NA		NA	1	Excess of nitric acid, of sodium hydroxide and of hydrochloric acid > 10%, formation of by-products
P3 Less hazardous chemical synthesis	1	Nitric acid and sulphuric acid, H314, methanol, H301, H311, H331, H370	1	Sodium hydroxide and hydrochloric acid, H314, and methanol, H301, H311, H331, H370		NA		NA	1	Nitric acid, sulphuric acid, sodium hydroxide and hydrochloric acid, H314, and methanol, H301, H311, H331, H370
P5 Safer solvents and auxiliary substances	1	Sulphuric acid, H314, and methanol, H301, H311, H331, H370	3	Water and activated charcoal	3	Water	3	1% hydrochloric acid solution	1	Sulphuric acid, H314, and methanol, H301, H311, H331, H370
P6 Increase energy efficiency	2	0 °C ≤ T ≤ 100 °C	1	T > 100 °C	2	0 °C ≤ T ≤ 100 °C	3	Room temperature	1	T > 100 °C
P7 Use renewable feedstocks	1	Substances not renewable	1	Substances not renewable	1	Substances not renewable	1	Substances not renewable	1	Substances not renewable
P8 Reduce derivatives	3	One stage	3	One stage		NA		NA	1	Three stages
P9 Catalysts	1	Sulphuric acid, H314	3	Without catalysts		NA		NA	1	Sulphuric acid, H314
P10 Design for degradation	1	Substances not degradable	1	Substances not degradable	1	Substances not degradable	1	Substances not degradable	1	Substances not degradable
P12 Safer chemistry for accident prevention	1	Nitric acid and sulphuric acid, H314, methanol, H225, H301, H311, H331, H370	1	Sodium hydroxide and hydrochloric acid, H314, and methanol, H225, H301, H311, H331, H370	1	Methanol, H225, H301, H311, H331, H370	2	3-nitrobenzoic acid, H302, H315, H319, H335	1	Nitric acid, sulphuric acid, sodium hydroxide and hydrochloric acid, H314, and methanol, H225, H301, H311, H331, H370

^as – Score; NA – Not applicable

References

- (1) Durst, H.D.; Gokel, G.W. *Experimental Organic Chemistry – 2nd edition*. McGraw-Hill Book Company: New York, 1987, pp. 493-495.