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October 1989

ENVIRONMENTAL IMPACT ANALYSIS OF THE MANUFACTURE OF SODIUM DODECYLBENZENESULFONATE AND LAURYLSULFATE

1. INFORMATION SOURCE

Firm specific data from a commercial scale manufacturer[1/].

2. PROCESS INFORMATION

2.1 Schematic illustration of the synthesis

27/6

2.2 Definition of educts, intermediates and products

The common names, chemical formulas and molecular weights of reactants and auxiliary chemicals are listed in appendix 1.

1/ CAOLA Cosmetic and Home Products Ltd., Budapest, Hungary.

2.3 Chemical reactions

(a) $S + O_2 = SO_2$

32.06 32.00 64.06

(b) $2SO_2 + O_2 = 2SO_3$

128.12 32.00 160.12

(c) $C_{18}H_{30} + SO_3 = C_{18}H_{29}SO_3H$

246.44 80.06 326.50

(d) $C_{18}H_{29}SO_3H + NaOH = C_{18}H_{29}SO_3Na + H_2O$

326.50 40.00 348.48 18.02

(e) Combined equation of the synthesis:

$2S + 3O_2 + 2C_{18}H_{30} + 2NaOH = 2C_{18}H_{29}SO_3Na + 2H_2O$

64.12 96.00 492.88 80.00 696.96 36.04

2.4 Other reactions considered in the analysis

(f) $C_{18}H_{30} + 2SO_3 = C_{18}H_{29}SO_2\text{-}O\text{-}SO_3H$

246.44 160.12 406.55

(g) $2C_{18}H_{30} + 2SO_3 = (C_{18}H_{29}SO_2)_2O + H_2O$

492.88 160.12 534.97 18.02

(h) $C_{18}H_{30} + C_{18}H_{29}SO_2\text{-}O\text{-}SO_3H = 2C_{18}H_{30}SO_3$

246.44 406.55 653.00

(i) $(C_{18}H_{29}SO_2)_2O + H_2O = 2C_{18}H_{30}O_3S$

534.97 18.02 653.00

(j) $C_{18}H_{30}O_6S_2 + H_2O = C_{18}H_{30}O_3S + H_2SO_4$

406.55 18.02 326.50 98.08

(k) $H_2SO_4 + 2NaOH = Na_2SO_4 + 2H_2O$

98.08 80.00 142.04 32.0

(l) $SO_2 + 2NaOH = Na_2SO_3 + H_2O$

64.06 80.00 126.04 18.02

2.5 Chemical conversion efficiencies

The molar chemical input conversion factors, F, the material input coefficients, f, and the overall yields, y, are given in table 1.

Table 1. Material conversion factors and yields

	F	f	y
Sulfur	0 092	0.104	88.5%
Dodecylbenzene	0.707	0.720	98.2%
Sodium hydroxide	0.115	0.130	88.5%

2.6 Brief description of the process

Sulfonation (or sulfatation in the case of sodium laurylsulfate) is carried out in film-reactor specially designed for the purpose. The sulfonating agent is a mixture of air and sulfurtrioxide, prepared by the combustion of sulfur (a by-product of petroleum refinery) to yield sulfurdioxide which is catalytically oxidized to sulfurtrioxide.

The manufacturing process consists of three stages: preparation of the air-sulfurtrioxide sulfonating agent from elementary sulfur, the sulfonation and subsequent neutralization, and the purification of process gases. The closed-system process is controlled by a computer.

The design and construction of the film reactor as well as the computer control of the process (temperature range, stoichiometric dosage of the feedstock and sulfonating agent) assure that the total quantity of sulfurtrioxide reacts with the feedstock and there is no need for recycling.

Small quantities of disulfonic acids and sulfonic acid anhydrides are also produced in the side reactions. These are converted upon standing, or as a result of hydrolisis, into the desired sulfonic acid which is reacted with sodium hydroxide to yield sodium dodecylsulfonate. The overall yield of the process is 98.2 per cent, with reference to dodecylbenzene.

3. ENVIRONMENT IMPACT ASSESSMENT

3.1 Material flow

The material flow schemas and informative material balances are shown in appendices 2 and 3, respectively.

3.2 Material requirements

Material requirements for the production of 1000 kg of dodecylbenzenesulfonate.

Sulfur	104 kg
Oxygene (air)	151 kg
Dodecylbenzene	720 kg
Sodium hydroxide	130 kg
	1,105 kg

Round 950 kg of materials are used, excluding oxygen from the air, for the production of 1,000 kg of sodium dodecylbenzenesulfonate. Nearly all material inputs are reactants.

3.3 Waste streams and treatments

Sulfonation of dodecylbenzene is carried out with a practically 100 per cent yield. Small amounts of dodecylbenzenesulfonic acid, sulfur dioxide and unreacted sulfur trioxide leave the sulfonation reactor. The finely dispersed dodecylbenzenesulfuric acid and sulfuric acid clouds are precipitated and collected, whereas the gaseous pollutants - sulfur oxides - are converted into salts in aqueous sodium hydroxide solution, so that the sulfur dioxide content of the emission is reduced below the tolerated limit.

3.3.1 Liquid effluents

Sulfonic acid and sulfuric acid are collected in the precipitator and sodium sulfite in the scrubbing liquid. All these materials are used in the manufacture of other products in the same location.

3.3.2 Air pollutants

The quantity of sulfur dioxide is 10 to 100 g in each cubic meter of air leaving the alkaline washing solution in the scrubber. This corresponds to about 4 kg of sulfur dioxide at a maximum production rate of 1000 kg sodium dodecylsulfonate per hour. The tolerated emission limit value in a highly polluted urban area is 28 kg per hour, if the chimney is 35 meters long, or higher, which is the case with the studied factory; therefore, the actual emission is one seventh of the maximum allowable concentration.

3.3.3 Solid wastes

Product-specific solid wastes are not generated in the process.

4. SUMMARY EVALUATION

5.1 per cent by-products are generated during the manufacture of sodium dodecylsulfonate; 92 per cent of the by-produced is used in the same factory. 8 per cent of the by-products, equivalent to 0.4 per cent of the main product, is fulfur dioxide. The technological emission is one seventh of the maximum allowable concentration in highly exposed areas, so the process is a modern, low-waste technology.

Another relevant point is that sulfur trioxide is prepared in situ from elementary sulfur, a by-product of the national crude oil refinery.

Appendix 1 to annex .. of the

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Reactants, products and auxiliary materials in the syntheses of sodium dodecylbenzenesulfonate and laurylsulfate

Table 1. Definition of chemicals in an anionic detergent synthesis

Compound	Molecular formula	Molecular weight
1-Dodecanol (lauryl alcohol)	$C_{12}H_{25}OH$	186.33
Dodecylbenzene	$C_{18}H_{30}$	246.44
Dodecylbenzenedisulfonic acid	$C_{18}H_{29}SO_2-O-SO_3H$	406.55
Dodecylbenzenesulfonic acid	$C_{18}H_{29}SO_3H$	326.50
Dodecylbenzenesulfonic acid anhydride	$(C_{18}H_{29}SO_2)_2O$	634.97
Lauryl sulfate	$C_{12}H_{26}O_4S$	266.39
Sodium dodecylbenzenesulfonate	$C_{18}H_{29}SO_3Na$	348.48
Sulfuric acid	H_2SO_4	98.08
Sodium sulfite	Na_2SO_3	126.04
Sulfur	S	32.06
Sulfur dioxide	SO_2	64.06
Sulfur trioxide	SO_3	80.06
Sodium hydroxide	NaOH	40.00

Appendix 2 to annex .. of the

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Appendix 3 to annex .. of the

ENVIRONMENTAL IMPACT ANALYSIS OF THE MANUFACTURE OF SODIUM DODECYLBENZENESULFONATE AND LAURYLSULFATE

Material balances for the manufacture of 1,000 kg of sodium dodecylbenzenesulfonate
(in kilogrammes)

Compound	Input	Output
Sulfur	104	
Oxygene (air)	151	
Dodecylbenzene	720	
Sodium hydroxide	130	
Sulfuric dioxide		4
Sodium sulfite		20
Alkylbenzenesulfonic and sulfuric acids		27
Water	2	
Sodium dodecylbenzene sulfonate		1,000
	1,107	1,107

Waste 1,107
-1,000
-56 51 kg