

*Eco-profiles of the
European Plastics Industry*

ACRYLONITRILE

A report by

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for

PlasticsEurope

Data last calculated

March 2005

IMPORTANT NOTE

Before using the data contained in this report, you are strongly recommended to look at the following documents:

1. Methodology

This provides information about the analysis technique used and gives advice on the meaning of the results.

2. Data sources

This gives information about the number of plants examined, the date when the data were collected and information about up-stream operations.

In addition, you can also download data sets for most of the upstream operations used in this report. All of these documents can be found at: www.plasticseurope.org.

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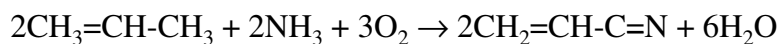
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CONTENTS

ACRYLONITRILE PRODUCTION	4
ECO-PROFILE OF ACRYLONITRILE	4

ACRYLONITRILE PRODUCTION

Acrylonitrile is produced by reacting propylene with ammonia in the presence of oxygen. The reaction follows the equation:



ECO-PROFILE OF ACRYLONITRILE

Table 1 shows the gross or cumulative energy to produce 1 kg of acrylonitrile and Table 2 gives this same data expressed in terms of primary fuels. Table 3 shows the energy data expressed as masses of fuels. Table 4 shows the raw materials requirements and Table 5 shows the demand for water. Table 6 shows the gross air emissions and Table 7 shows the corresponding carbon dioxide equivalents of these air emissions. Table 8 shows the emissions to water. Table 9 shows the solid waste generated and Table 10 gives the solid waste in EU format.

Table 1

Gross energy required to produce 1 kg of acrylonitrile. (Totals may not agree because of rounding)

Fuel type	Fuel prod'n & delivery energy (MJ)	Energy content of delivered fuel (MJ)	Energy use in transport (MJ)	Feedstock energy (MJ)	Total energy (MJ)
Electricity	4.32	1.51	0.45	-	6.28
Oil fuels	0.33	14.80	0.09	27.51	42.74
Other fuels	1.09	14.82	0.02	20.26	36.19
Totals	5.75	31.13	0.57	47.77	85.21

Table 2

Gross primary fuels required to produce 1 kg of acrylonitrile. (Totals may not agree because of rounding)

Fuel type	Fuel prod'n & delivery energy (MJ)	Energy content of delivered fuel (MJ)	Fuel use in transport (MJ)	Feedstock energy (MJ)	Total energy (MJ)
Coal	1.03	1.47	0.15	<0.01	2.65
Oil	1.05	15.10	0.17	27.51	43.83
Gas	2.23	19.80	0.14	20.12	42.28
Hydro	0.14	0.07	<0.01	-	0.22
Nuclear	1.07	0.39	0.10	-	1.57
Lignite	0.10	0.11	<0.01	-	0.20
Wood	<0.01	<0.01	<0.01	<0.01	<0.01
Sulphur	<0.01	<0.01	<0.01	0.13	0.13
Biomass (solid)	0.02	0.01	<0.01	<0.01	0.03
Hydrogen	<0.01	<0.01	<0.01	-	<0.01
Recovered energy	<0.01	-5.86	<0.01	-	-5.86
Unspecified	<0.01	<0.01	<0.01	-	<0.01
Peat	<0.01	<0.01	<0.01	-	<0.01
Geothermal	0.04	0.02	<0.01	-	0.07
Solar	<0.01	<0.01	<0.01	-	<0.01
Wave/tidal	<0.01	<0.01	<0.01	-	<0.01
Biomass (liquid/gas)	0.03	0.01	0.01	-	0.05
Industrial waste	<0.01	<0.01	<0.01	-	<0.01
Municipal Waste	0.02	0.01	<0.01	-	0.03
Wind	<0.01	<0.01	<0.01	-	0.01
Totals	5.74	31.13	0.57	47.77	85.21

Table 3

Gross primary fuels used to produce 1 kg of acrylonitrile expressed as mass.

Fuel type	Input in mg
Crude oil	970000
Gas/condensate	810000
Coal	93000
Metallurgical coal	92
Lignite	14000
Peat	360
Wood	7

Table 4
Gross raw materials required to produce 1 kg of acrylonitrile.

Raw material	Input in mg
Air	740000
Animal matter	<1
Barytes	<1
Bauxite	1
Bentonite	55
Biomass (including water)	8600
Calcium sulphate (CaSO ₄)	5
Chalk (CaCO ₃)	<1
Clay	<1
Cr	<1
Cu	<1
Dolomite	3
Fe	230
Feldspar	<1
Ferromanganese	<1
Fluorspar	<1
Granite	<1
Gravel	1
Hg	<1
Limestone (CaCO ₃)	780
Mg	<1
N ₂	120000
Ni	<1
O ₂	4
Olivine	2
Pb	<1
Phosphate as P ₂ O ₅	<1
Potassium chloride (KCl)	<1
Quartz (SiO ₂)	<1
Rutile	<1
S (bonded)	<1
S (elemental)	15000
Sand (SiO ₂)	65
Shale	15
Sodium chloride (NaCl)	2400
Sodium nitrate (NaNO ₃)	<1
Talc	<1
Unspecified	<1
Zn	<1

Table 5
Gross water consumption required for the production of 1 kg of acrylonitrile. (Totals may not agree because of rounding)

Source	Use for processing (mg)	Use for cooling (mg)	Totals (mg)
Public supply	4200000	-	4200000
River canal	1700000	104000000	106000000
Sea	230000	2000000	2200000
Well	8200	<1	8200
Unspecified	3400000	25000000	28000000
Totals	9600000	131000000	140000000

Table 6

Gross air emissions associated with the production of 1 kg of acrylonitrile.
(Totals may not agree because of rounding)

Emission	From fuel prod'n (mg)	From fuel use (mg)	From transport (mg)	From process (mg)	From biomass (mg)	From fugitive (mg)	Totals (mg)
dust (PM10)	490	160	2	240	-	-	890
CO	1300	650	18	13000	-	-	15000
CO2	390000	1300000	8400	1100000	-6	-	2800000
SOX as SO2	2000	2900	140	4300	-	-	9300
H2S	<1	-	<1	<1	-	-	<1
mercaptan	<1	<1	<1	<1	-	-	<1
NOX as NO2	1500	2000	51	690	-	-	4200
NH3	<1	-	<1	13	-	-	13
Cl2	<1	<1	<1	<1	-	-	<1
HCl	29	20	<1	<1	-	-	48
F2	<1	<1	<1	<1	-	-	<1
HF	1	1	<1	<1	-	-	2
hydrocarbons not specified	1100	190	16	6100	-	<1	7400
aldehyde (-CHO)	<1	-	<1	<1	-	-	<1
organics	<1	<1	<1	580	-	-	580
Pb+compounds as Pb	<1	<1	<1	<1	-	-	<1
Hg+compounds as Hg	<1	-	<1	<1	-	-	<1
metals not specified elsewhere	1	1	<1	<1	-	-	2
H2SO4	<1	-	<1	<1	-	-	<1
N2O	<1	<1	<1	<1	-	-	<1
H2	36	<1	<1	1	-	-	37
dichloroethane (DCE) C2H4Cl2	<1	-	<1	<1	-	<1	<1
vinyl chloride monomer (VCM)	<1	-	<1	<1	-	<1	<1
CFC/HCFC/HFC not specified	<1	-	<1	<1	-	-	<1
organo-chlorine not specified	<1	-	<1	<1	-	-	<1
HCN	<1	-	<1	1	-	-	1
CH4	15000	400	<1	3100	-	<1	18000
aromatic HC not specified elsewhere	<1	-	<1	38	-	<1	38
polycyclic hydrocarbons (PAH)	<1	<1	<1	<1	-	-	<1
NM VOC	<1	-	<1	18	-	-	18
CS2	<1	-	<1	<1	-	-	<1
methylene chloride CH2Cl2	<1	-	<1	<1	-	-	<1
Cu+compounds as Cu	<1	<1	<1	<1	-	-	<1
As+compounds as As	-	-	-	<1	-	-	<1
Cd+compounds as Cd	<1	-	<1	<1	-	-	<1
Ag+compounds as Ag	-	-	-	<1	-	-	<1
Zn+compounds as Zn	<1	-	<1	<1	-	-	<1
Cr+compounds as Cr	<1	<1	<1	<1	-	-	<1
Se+compounds as Se	-	-	-	<1	-	-	<1
Ni+compounds as Ni	<1	<1	<1	<1	-	-	<1
Sb+compounds as Sb	-	-	<1	<1	-	-	<1
ethylene C2H4	-	-	<1	3	-	-	3
oxygen	-	-	-	<1	-	-	<1
asbestos	-	-	-	<1	-	-	<1
dioxin/furan as Teq	-	-	-	<1	-	-	<1
benzene C6H6	-	-	-	<1	-	<1	<1
toluene C7H8	-	-	-	<1	-	<1	<1
xylenes C8H10	-	-	-	<1	-	<1	<1
ethylbenzene C8H10	-	-	-	<1	-	<1	<1
styrene	-	-	-	<1	-	<1	<1
propylene	-	-	-	2	-	-	2

Table 7

Carbon dioxide equivalents corresponding to the gross air emissions for the production of 1 kg of acrylonitrile. (Totals may not agree because of rounding)

Type	From fuel prod'n (mg)	From fuel use (mg)	From transport (mg)	From process (mg)	From biomass (mg)	From fugitive (mg)	Totals (mg)
20 year equiv	1300000	1300000	8500	1300000	-6	<1	4000000
100 year equiv	740000	1300000	8500	1200000	-6	<1	3200000
500 year equiv	510000	1300000	8500	1100000	-6	<1	2900000

Table 8

Gross emissions to water arising from the production of 1 kg of acrylonitrile.
(Totals may not agree because of rounding).

Emission	From fuel prod'n (mg)	From fuel use (mg)	From transport (mg)	From process (mg)	Totals (mg)
COD	1	-	<1	3700	3700
BOD	<1	-	<1	20	20
Pb+compounds as Pb	<1	-	<1	<1	<1
Fe+compounds as Fe	<1	-	<1	<1	<1
Na+compounds as Na	<1	-	<1	640	640
acid as H+	<1	-	<1	1	1
NO ₃ -	<1	-	<1	2	2
Hg+compounds as Hg	<1	-	<1	<1	<1
metals not specified elsewhere	<1	-	<1	7	7
ammonium compounds as NH ₄ +	1	-	<1	1700	1700
Cl-	<1	-	<1	930	930
CN-	<1	-	<1	29	29
F-	<1	-	<1	<1	<1
S+sulphides as S	<1	-	<1	<1	<1
dissolved organics (non-	<1	-	<1	10	10
suspended solids	26	-	2	140	170
detergent/oil	<1	-	<1	10	10
hydrocarbons not specified	7	<1	<1	<1	7
organo-chlorine not specified	<1	-	<1	<1	<1
dissolved chlorine	<1	-	<1	<1	<1
phenols	<1	-	<1	1	1
dissolved solids not specified	<1	-	<1	5000	5000
P+compounds as P	<1	-	<1	<1	<1
other nitrogen as N	<1	-	<1	300	300
other organics not specified	<1	-	<1	<1	<1
SO ₄ --	<1	-	<1	5500	5500
dichloroethane (DCE)	<1	-	<1	<1	<1
vinyl chloride monomer (VCM)	<1	-	<1	<1	<1
K+compounds as K	<1	-	<1	<1	<1
Ca+compounds as Ca	<1	-	<1	<1	<1
Mg+compounds as Mg	<1	-	<1	<1	<1
Cr+compounds as Cr	<1	-	<1	<1	<1
ClO ₃ --	<1	-	<1	<1	<1
BrO ₃ --	<1	-	<1	<1	<1
TOC	<1	-	<1	2400	2400
AOX	<1	-	<1	<1	<1
Al+compounds as Al	<1	-	<1	<1	<1
Zn+compounds as Zn	<1	-	<1	<1	<1
Cu+compounds as Cu	<1	-	<1	<1	<1
Ni+compounds as Ni	<1	-	<1	<1	<1
CO ₃ --	-	-	<1	51	51
As+compounds as As	-	-	<1	<1	<1
Cd+compounds as Cd	-	-	<1	<1	<1
Mn+compounds as Mn	-	-	<1	<1	<1
organo-tin as Sn	-	-	<1	<1	<1
Sr+compounds as Sr	-	-	<1	<1	<1
organo-silicon	-	-	-	<1	<1
benzene	-	-	-	<1	<1
dioxin/furan as Teq	-	-	<1	<1	<1

Table 9

*Gross solid waste associated with the production of 1 kg of acrylonitrile.
(Totals may not agree because of rounding)*

Emission	From fuel prod'n (mg)	From fuel use (mg)	From transport (mg)	From process (mg)	Totals (mg)
Plastic containers	<1	-	<1	<1	<1
Paper	<1	-	<1	<1	<1
Plastics	<1	-	<1	2	2
Metals	<1	-	<1	<1	<1
Putrescibles	<1	-	<1	<1	<1
Unspecified refuse	1100	-	<1	<1	1100
Mineral waste	3200	-	22	380	3600
Slags & ash	4500	2200	8	690	7400
Mixed industrial	890	-	1	530	1400
Regulated chemicals	1400	-	<1	5100	6500
Unregulated chemicals	1000	-	<1	210	1300
Construction waste	<1	-	<1	<1	<1
Waste to incinerator	<1	-	<1	87	87
Inert chemical	<1	-	<1	480	480
Wood waste	<1	-	<1	<1	<1
Wooden pallets	<1	-	<1	<1	<1
Waste to recycling	<1	-	<1	310	310
Waste returned to mine	17000	-	1	1	17000
Tailings	1	-	1	<1	1
Municipal solid waste	-2500	-	-	<1	-2500
Note: Negative values correspond to consumption of waste e.g. recycling or use in electricity generation.					

Table 10

Gross solid waste in EU format associated with the production of 1 kg of acrylonitrile. Entries marked with an asterisk (*) are considered hazardous as defined by EU Directive 91/689/EEC

Emission	Totals (mg)
010101 metallic min'l excav'n waste	250
010102 non-metal min'l excav'n waste	17000
010306 non 010304/010305 tailings	1
010308 non-010307 powdery wastes	1
010399 unspecified met. min'l wastes	27
010408 non-010407 gravel/crushed rock	<1
010410 non-010407 powdery wastes	<1
010411 non-010407 potash/rock salt	9
010499 unsp'd non-met. waste	<1
010505*oil-bearing drilling mud/waste	1300
010508 non-010504/010505 chloride mud	1000
010599 unspecified drilling mud/waste	1100
020107 wastes from forestry	<1
050106*oil ind. oily maint'e sludges	5
050107*oil industry acid tars	220
050199 unspecified oil industry waste	230
050699 coal pyrolysis unsp'd waste	11
060101*H ₂ SO ₄ /H ₂ SO ₃ MFSU waste	<1
060102*HCl MFSU waste	<1
060106*other acidic MFSU waste	<1
060199 unsp'd acid MFSU waste	<1
060204*NaOH/KOH MFSU waste	<1
060299 unsp'd base MFSU waste	<1
060313*h. metal salt/sol'n MFSU waste	4
060314 other salt/sol'n MFSU waste	<1
060399 unsp'd salt/sol'n MFSU waste	1
060404*Hg MFSU waste	<1
060405*other h. metal MFSU waste	<1
060499 unsp'd metallic MFSU waste	1
060602*dangerous sulphide MFSU waste	<1
060603 non-060602 sulphide MFSU waste	29
060701*halogen electrol. asbestos waste	<1
060702*Cl pr. activated C waste	<1
060703*BaSO ₄ sludge with Hg	<1
060704*halogen pr. acids and sol'ns	1
060799 unsp'd halogen pr. waste	1
061002*N ind. dangerous sub. waste	<1
061099 unsp'd N industry waste	<1
070101*organic chem. aqueous washes	<1
070103*org. halogenated solv'ts/washes	<1
070107*hal'd still bottoms/residues	<1
070108*other still bottoms/residues	12
070111*org. chem. dan. eff. sludge	<1
070112 non-070111 effluent sludge	<1
070199 unsp'd organic chem. waste	23
070204*polymer ind. other washes	<1

continued over

Table 10 - continued

Gross solid waste in EU format associated with the production of 1 kg of acrylonitrile. Entries marked with an asterisk () are considered hazardous as defined by EU Directive 91/689/EEC*

070207*polymer ind. hal'd still waste	<1
070208*polymer ind. other still waste	410
070209*polymer ind. hal'd fil. cakes	<1
070213 polymer ind. waste plastic	1
070214*polymer ind. dan. additives	210
070216 polymer ind. silicone wastes	<1
070299 unsp'd polymer ind. waste	340
080199 unspecified paint/varnish waste	<1
100101 non-100104 ash, slag & dust	5800
100102 coal fly ash	600
100104*oil fly ash and boiler dust	<1
100105 FGD Ca-based reac. solid waste	<1
100113*emulsified hydrocarbon fly ash	<1
100114*dangerous co-incin'n ash/slag	37
100115 non-100115 co-incin'n ash/slag	1
100116*dangerous co-incin'n fly ash	<1
100199 unsp'd thermal process waste	<1
100202 unprocessed iron/steel slag	67
100210 iron/steel mill scales	5
100399 unspecified aluminium waste	<1
100501 primary/secondary zinc slags	<1
100504 zinc pr. other dust	<1
100511 non-100511 Zn pr. skimmings	<1
101304 lime calcin'n/hydration waste	8
130208*other engine/gear/lub. oil	<1
150101 paper and cardboard packaging	<1
150102 plastic packaging	<1
150103 wooden packaging	<1
150106 mixed packaging	<1
170107 non-170106 con'e/brick/tile mix	<1
170904 non-170901/2/3 con./dem'n waste	<1
190199 unspecified incin'n/pyro waste	<1
190905 sat./spent ion exchange resins	480
200101 paper and cardboard	<1
200108 biodeg. kitchen/canteen waste	<1
200138 non-200137 wood	<1
200139 plastics	1
200140 metals	<1
200199 other separately coll. frac'ns	-240
200301 mixed municipal waste	1
200399 unspecified municipal wastes	-1300
Note: Negative values correspond to consumption of waste e.g. recycling or use in electricity generation.	