

*Eco-profiles of the
European Plastics Industry*

POLYBUTADIENE

A report by

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for

PlasticsEurope

Data last calculated

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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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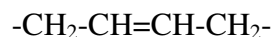
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POLYBUTADIENE PRODUCTION

Butadiene readily polymerises to yield a polymer with a repeat unit:



Note that the polymer contains a double bond and this is useful as a reactive site to form cross links and reactions with other polymers.

ECO-PROFILE OF POLYBUTADIENE

Table 1 shows the gross or cumulative energy to produce 1 kg of polybutadiene 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 polybutadiene. (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	6.07	2.34	0.42	-	8.83
Oil fuels	0.94	16.87	0.12	35.84	53.77
Other fuels	1.33	30.00	0.06	8.37	39.76
Totals	8.34	49.22	0.60	44.20	102.36

Table 2

Gross primary fuels required to produce 1 kg of polybutadiene. (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	2.21	4.85	0.13	<0.01	7.19
Oil	1.25	17.08	0.25	35.84	54.42
Gas	2.94	26.39	0.12	8.37	37.81
Hydro	0.10	0.05	<0.01	-	0.15
Nuclear	1.70	0.69	0.09	-	2.47
Lignite	<0.01	<0.01	<0.01	-	<0.01
Wood	<0.01	<0.01	<0.01	<0.01	<0.01
Sulphur	<0.01	<0.01	<0.01	<0.01	<0.01
Biomass (solid)	0.03	0.01	<0.01	<0.01	0.04
Hydrogen	<0.01	<0.01	<0.01	-	<0.01
Recovered energy	<0.01	0.11	<0.01	-	0.11
Unspecified	<0.01	<0.01	<0.01	-	<0.01
Peat	<0.01	<0.01	<0.01	-	<0.01
Geothermal	<0.01	<0.01	<0.01	-	<0.01
Solar	<0.01	<0.01	<0.01	-	<0.01
Wave/tidal	<0.01	<0.01	<0.01	-	<0.01
Biomass (liquid/gas)	0.05	0.02	<0.01	-	0.07
Industrial waste	0.01	0.01	<0.01	-	0.02
Municipal Waste	0.03	0.01	<0.01	-	0.04
Wind	0.01	0.01	<0.01	-	0.02
Totals	8.34	49.22	0.60	44.20	102.36

Table 3

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

Fuel type	Input in mg
Crude oil	1200000
Gas/condensate	730000
Coal	250000
Metallurgical coal	82
Lignite	1
Peat	210
Wood	4

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

Raw material	Input in mg
Air	48000
Animal matter	<1
Barytes	<1
Bauxite	25
Bentonite	29
Biomass (including water)	13000
Calcium sulphate (CaSO ₄)	3
Chalk (CaCO ₃)	<1
Clay	<1
Cr	<1
Cu	8
Dolomite	2
Fe	200
Feldspar	<1
Ferromanganese	<1
Fluorspar	1
Granite	<1
Gravel	1
Hg	<1
Limestone (CaCO ₃)	130
Mg	<1
N ₂	39000
Ni	<1
O ₂	5
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)	30
Sand (SiO ₂)	75
Shale	8
Sodium chloride (NaCl)	430
Sodium nitrate (NaNO ₃)	<1
Talc	<1
Unspecified	<1
Zn	<1

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

Source	Use for processing (mg)	Use for cooling (mg)	Totals (mg)
Public supply	8500000	-	8500000
River canal	410000	20000	430000
Sea	210000	1400000	1600000
Well	<1	<1	1
Unspecified	680000	17000000	18000000
Totals	9800000	19000000	28000000

Table 6

Gross air emissions associated with the production of 1 kg of polybutadiene.
(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)	580	550	3	200	-	-	1300
CO	2000	950	38	470	-	-	3400
CO2	600000	2600000	13000	310000	-4	-	3500000
SOX as SO2	2200	10000	180	580	-	-	13000
H2S	<1	-	<1	<1	-	-	<1
mercaptan	<1	<1	<1	<1	-	-	<1
NOX as NO2	2000	5300	85	260	-	-	7700
NH3	<1	-	<1	<1	-	-	<1
Cl2	<1	<1	<1	<1	-	-	<1
HCl	61	80	<1	<1	-	-	140
F2	<1	<1	<1	<1	-	-	<1
HF	2	3	<1	<1	-	-	5
hydrocarbons not specified	1300	620	26	7200	-	<1	9100
aldehyde (-CHO)	<1	-	<1	<1	-	-	<1
organics	<1	<1	<1	75	-	-	75
Pb+compounds as Pb	<1	<1	<1	<1	-	-	<1
Hg+compounds as Hg	<1	-	<1	<1	-	-	<1
metals not specified elsewhere	<1	5	<1	<1	-	-	6
H2SO4	<1	-	<1	<1	-	-	<1
N2O	<1	<1	<1	<1	-	-	<1
H2	61	<1	<1	1	-	-	62
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	13000	1100	<1	2200	-	<1	16000
aromatic HC not specified	<1	-	<1	180	-	21	200
polycyclic hydrocarbons (PAH)	<1	<1	<1	<1	-	-	<1
NM VOC	<1	-	<1	34	-	-	34
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	2	-	-	2
oxygen	-	-	-	<1	-	-	<1
asbestos	-	-	-	<1	-	-	<1
dioxin/furan as Teq	-	-	-	<1	-	-	<1
benzene C6H6	-	-	-	<1	-	<1	<1
toluene C7H8	-	-	-	<1	-	<1	<1
xylene 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 polybutadiene. (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	1400000	2600000	13000	470000	-4	<1	4500000
100 year equiv	910000	2600000	13000	380000	-4	<1	3900000
500 year equiv	700000	2600000	13000	350000	-4	<1	3600000

Table 8

Gross emissions to water arising from the production of 1 kg of polybutadiene.
(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	2	-	<1	730	730
BOD	1	-	<1	200	200
Pb+compounds as Pb	<1	-	<1	<1	<1
Fe+compounds as Fe	<1	-	<1	<1	<1
Na+compounds as Na	<1	-	<1	82	82
acid as H+	1	-	<1	1	2
NO3-	<1	-	<1	2	2
Hg+compounds as Hg	<1	-	<1	<1	<1
metals not specified elsewhere	<1	-	<1	6	6
ammonium compounds as NH4+	1	-	<1	2	3
Cl-	1	-	<1	71	72
CN-	<1	-	<1	<1	<1
F-	<1	-	<1	<1	<1
S+sulphides as S	<1	-	<1	<1	<1
dissolved organics (non-	1	-	<1	12	13
suspended solids	61	-	6	180	250
detergent/oil	<1	-	<1	12	12
hydrocarbons not specified	3	<1	<1	2	5
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	24	24
P+compounds as P	<1	-	<1	<1	<1
other nitrogen as N	<1	-	<1	1	1
other organics not specified	<1	-	<1	<1	<1
SO4--	<1	-	<1	370	370
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
ClO3--	<1	-	<1	<1	<1
BrO3--	<1	-	<1	<1	<1
TOC	<1	-	<1	17	17
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
CO3--	-	-	<1	45	45
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 polybutadiene.
(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	1	1
Metals	<1	-	<1	<1	<1
Putrescibles	<1	-	<1	<1	<1
Unspecified refuse	2300	-	<1	<1	2300
Mineral waste	28	-	60	140	220
Slags & ash	8800	8000	23	32	17000
Mixed industrial	1300	-	2	570	1900
Regulated chemicals	2800	-	<1	1100	3900
Unregulated chemicals	2100	-	<1	1800	3900
Construction waste	<1	-	<1	<1	<1
Waste to incinerator	<1	-	<1	7200	7200
Inert chemical	<1	-	<1	600	600
Wood waste	<1	-	<1	<1	<1
Wooden pallets	<1	-	<1	<1	<1
Waste to recycling	<1	-	<1	1400	1400
Waste returned to mine	49000	-	2	640	50000
Tailings	1	-	2	310	320
Municipal solid waste	-4200	-	-	96	-4100
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 polybutadiene. 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	180
010102 non-metal min'l excav'n waste	49000
010306 non 010304/010305 tailings	3
010308 non-010307 powdery wastes	3
010399 unspecified met. min'l wastes	1
010408 non-010407 gravel/crushed rock	<1
010410 non-010407 powdery wastes	<1
010411 non-010407 potash/rock salt	1
010499 unsp'd non-met. waste	<1
010505*oil-bearing drilling mud/waste	2700
010508 non-010504/010505 chloride mud	2100
010599 unspecified drilling mud/waste	2300
020107 wastes from forestry	<1
050106*oil ind. oily maint'e sludges	11
050107*oil industry acid tars	250
050199 unspecified oil industry waste	330
050699 coal pyrolysis unsp'd waste	17
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	1
060314 other salt/sol'n MFSU waste	<1
060399 unsp'd salt/sol'n MFSU waste	13
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	<1
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	6900
070111*org. chem. dan. eff. sludge	<1
070112 non-070111 effluent sludge	<1
070199 unsp'd organic chem. waste	19

continued over

Table 10 - continued

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

070204*polymer ind. other washes	210
070207*polymer ind. hal'd still waste	<1
070208*polymer ind. other still waste	1000
070209*polymer ind. hal'd fil. cakes	<1
070213 polymer ind. waste plastic	1
070214*polymer ind. dan. additives	330
070216 polymer ind. silicone wastes	<1
070299 unsp'd polymer ind. waste	2000
080199 unspecified paint/varnish waste	<1
100101 non-100104 ash, slag & dust	17000
100102 coal fly ash	<1
100104*oil fly ash and boiler dust	<1
100105 FGD Ca-based reac. solid waste	<1
100113*emulsified hyrdocarbon fly ash	<1
100114*dangerous co-incin'n ash/slag	<1
100115 non-100115 co-incin'n ash/slag	<1
100116*dangerous co-incin'n fly ash	<1
100199 unsp'd themal process waste	<1
100202 unprocessed iron/steel slag	60
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	4
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	600
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	22
200301 mixed municipal waste	1
200399 unspecified municipal wastes	-1800
Note: Negative values correspond to consumption of waste e.g. recycling or use in electricity generation.	