Description

Image



Caption

1. Wine bottles. © iStockphoto 2. Building windows. © John Fernandez 3. Building windows. © John Fernandez

The material

Soda lime glass is the glass of windows, bottles and light bulbs, used in vast quantities, the commonest of them all. The name suggests its composition: 13-17% NaO (the "soda"), 5-10% CaO (the "lime") and 70-75% SiO2 (the "glass"). It has a low melting point, is easy to blow and mold, and it is cheap. It is optically clear unless impure, when it is typically green or brown. Windows today have to be flat and that was not - until 1950 - easy to do; now the float-glass process, solidifying glass on a bed of liquid tin, makes 'plate' glass cheaply and quickly.

Composition (summary)

73% SiO2/1% Al2O3/17% Na2O/4% MgO/5% CaO

General properties

Density	2.44e3	-	2.49e3	kg/m^3
Price	* 1.41	-	1.66	USD/kg
Date first used	-3500			

Mechanical properties

Young's modulus	68	-	72	GPa
Shear modulus	28	-	29.5	GPa
Bulk modulus	39.8	-	41.9	GPa
Poisson's ratio	0.21	-	0.22	
Yield strength (elastic limit)	* 30	-	35	MPa
Tensile strength	31	-	35	MPa
Compressive strength	* 360	-	420	MPa
Elongation	0			% strain
Hardness - Vickers	439	-	484	HV
Fatigue strength at 10^7 cycles	* 29.4	-	32.5	MPa
Fracture toughness	* 0.55	-	0.7	MPa.m^0.5

Mechanical loss coefficient (tan delta)		7.5e-4	-	8.8e-4	

Thermal properties

Glass temperature		442	-	592	℃
Maximum service temperature		170	-	400	℃
Minimum service temperature		-273			℃
Thermal conductor or insulator?		Poor insulator			
Thermal conductivity	*	0.7	-	1.3	W/m.℃
Specific heat capacity	*	850	-	950	J/kg.℃
Thermal expansion coefficient		9.1	-	9.5	µstrain/℃

Electrical properties

Electrical conductor or insulator?		Good insulator			
Electrical resistivity		7.94e17	-	7.94e18	µohm.cm
Dielectric constant (relative permittivity)		7	-	7.6	
Dissipation factor (dielectric loss tangent)		0.007	-	0.01	
Dielectric strength (dielectric breakdown)	*	12	-	14	1000000 V/m

Optical properties

Transparency		Optical Quality			
Refractive index		1.5	-	1.52	

Critical Materials Risk

High critical material risk?		No			

Processability

Castability		3	-	4	
Moldability		5			
Weldability		3	-	4	

Durability: water and aqueous solutions

Water (fresh)		Excellent			
Water (salt)		Excellent			
Soils, acidic (peat)		Excellent			
Soils, alkaline (clay)		Excellent			
Wine		Excellent			

Durability: acids

Acetic acid (10%)		Excellent			
Acetic acid (glacial)		Excellent			
Citric acid (10%)		Excellent			
Hydrochloric acid (10%)		Excellent			

Hydrochloric acid (36%)	Excellent
Hydrofluoric acid (40%)	Unacceptable
Nitric acid (10%)	Excellent
Nitric acid (70%)	Excellent
Phosphoric acid (10%)	Excellent
Phosphoric acid (85%)	Excellent
Sulfuric acid (10%)	Excellent
Sulfuric acid (70%)	Excellent

Durability: alkalis

Sodium hydroxide (10%)	Acceptable
Sodium hydroxide (60%)	Limited use

Durability: fuels, oils and solvents

Amyl acetate	Excellent
Benzene	Excellent
Carbon tetrachloride	Excellent
Chloroform	Excellent
Crude oil	Excellent
Diesel oil	Excellent
Lubricating oil	Excellent
Paraffin oil (kerosene)	Excellent
Petrol (gasoline)	Excellent
Silicone fluids	Excellent
Toluene	Excellent
Turpentine	Excellent
Vegetable oils (general)	Excellent
White spirit	Excellent

Durability: alcohols, aldehydes, ketones

Acetaldehyde	Excellent
Acetone	Excellent
Ethyl alcohol (ethanol)	Excellent
Ethylene glycol	Excellent
Formaldehyde (40%)	Excellent
Glycerol	Excellent
Methyl alcohol (methanol)	Excellent

Durability: halogens and gases

Chlorine gas (dry)	Excellent
Fluorine (gas)	Limited use

O2 (oxygen gas)	Excellent
Sulfur dioxide (gas)	Excellent

Durability: built environments

Industrial atmosphere	Excellent
Rural atmosphere	Excellent
Marine atmosphere	Excellent
UV radiation (sunlight)	Excellent

Durability: flammability

Flammability	Non-flammable

Durability: thermal environments

Tolerance to cryogenic temperatures	Excellent
Tolerance up to 150 C (302 F)	Excellent
Tolerance up to 250 C (482 F)	Excellent
Tolerance up to 450 C (842 F)	Unacceptable
Tolerance up to 850 C (1562 F)	Unacceptable
Tolerance above 850 C (1562 F)	Unacceptable

Geo-economic data for principal component

Annual world production, principal component		8e7	-	8.2e7	tonne/yr
Reserves, principal component	*	1e10	-	1.1e10	tonne

Primary material production: energy, CO2 and water

Embodied energy, primary production	*	10.1	-	11.1	MJ/kg
CO2 footprint, primary production	*	0.72	-	0.796	kg/kg
Water usage	*	13.6	-	15.1	l/kg
Eco-indicator 95		50.5			millipoints/kg
Eco-indicator 99		75.7			millipoints/kg

Material processing: energy

Glass molding energy	*	7.82	-	9.46	MJ/kg
Grinding energy (per unit wt removed)	*	25.6	-	28.3	MJ/kg

Material processing: CO2 footprint

Glass molding CO2	*	0.625	-	0.757	kg/kg
Grinding CO2 (per unit wt removed)	*	1.92	-	2.12	kg/kg

Material recycling: energy, CO2 and recycle fraction

Recycle	✓				
Embodied energy, recycling	*	7.81	-	8.64	MJ/kg

CO2 footprint, recycling	* 0.614	-	0.679	kg/kg
Recycle fraction in current supply	22	-	26	%
Downcycle	✓			
Combust for energy recovery	✗			
Landfill	✓			
Biodegrade	✗			
Toxicity rating	Non-toxic			
A renewable resource?	✗			

Environmental notes

Silica, the prime ingredient of glass, is the commonest compound in the earths crust, though it is harder to find it in a form sufficiently pure to make glass. Nonetheless, the ingredients of glass are ubiquitous, and the material is readily recycled at the end of its life.

Supporting information

Design guidelines

Soda lime glass is an exceptionally versatile material. It is easily cast, rolled, blow-molded, pressure molded or drawn to a great variety of shapes. It can be cut, polished, and toughened. It is an exceptionally durable material, surviving weathering and normal handling with no trace of degradation, sometimes for hundreds of years.

Typical uses

Windows, bottles, containers, tubing, lamp bulbs, lenses and mirrors, bells, glazes on ceramics.

Links

Reference

ProcessUniverse

Producers