

## Description

### Image



### Caption

1. Close-up of the material. © John Fernandez 2. Cork, used to make wine bottle stoppers (corks). © Chris Leferi 3. Cork is the bark of the cork oak, Quercus Suber. © Granta Design

### The material

Cork is a natural closed-cell foam, and is waterproof and remarkably stable, surviving in the neck of a wine bottle for 50 years or more without decay or contaminating the wine. Corkboard, made by compressing granulated cork under heat, is used for wall and ceiling insulation. Cork itself has a remarkable combination of properties. It is light yet resilient, insulates against heat and sound, has a high coefficient of friction, is imperious to liquids, chemically stable and fire resistant. Demand for cork exceeds 500,000 tones per year - and one tonne of cork has the same volume as 56 tonnes of steel.

### Compositional summary

40% Suberin / 27% Lignin / 12% Cellulose / 4% Friedelin / 17% Water

## General properties

Density	120	-	240	kg/m <sup>3</sup>
Price	* 2.68	-	13.4	USD/kg
Date first used	-3000			

## Mechanical properties

Young's modulus	0.013	-	0.05	GPa
Shear modulus	0.0025	-	0.008	GPa
Bulk modulus	0.01	-	0.018	GPa
Poisson's ratio	0.05	-	0.45	
Yield strength (elastic limit)	* 0.3	-	1.5	MPa
Tensile strength	0.5	-	2.5	MPa
Compressive strength	0.54	-	2	MPa
Elongation	20	-	80	% strain

Fatigue strength at 10 <sup>7</sup> cycles	0.3	-	1.1	MPa
Fracture toughness	0.05	-	0.1	MPa.m <sup>0.5</sup>
Mechanical loss coefficient (tan delta)	0.1	-	0.3	

### Thermal properties

Glass temperature	76.9	-	102	°C
Maximum service temperature	117	-	137	°C
Minimum service temperature	-73.2	-	-23.2	°C
Thermal conductor or insulator?	Good insulator			
Thermal conductivity	0.035	-	0.048	W/m.°C
Specific heat capacity	1.9e3	-	2.1e3	J/kg.°C
Thermal expansion coefficient	130	-	230	µstrain/°C

### Electrical properties

Electrical conductor or insulator?	Poor insulator			
Electrical resistivity	* 1e9	-	1e11	µohm.cm
Dielectric constant (relative permittivity)	* 6	-	8	
Dissipation factor (dielectric loss tangent)	* 0.02	-	0.05	
Dielectric strength (dielectric breakdown)	* 1	-	2	1000000 V/m

### Optical properties

Transparency	Opaque			
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### Processability

Moldability	3	-	4	
Machinability	4			

### Durability: water and aqueous solutions

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

### Durability: acids

Acetic acid (10%)	Acceptable			
Acetic acid (glacial)	Limited use			
Citric acid (10%)	Acceptable			
Hydrochloric acid (10%)	Acceptable			
Hydrochloric acid (36%)	Unacceptable			
Hydrofluoric acid (40%)	Unacceptable			
Nitric acid (10%)				

	Acceptable
Nitric acid (70%)	Unacceptable
Phosphoric acid (10%)	Acceptable
Phosphoric acid (85%)	Unacceptable
Sulfuric acid (10%)	Acceptable
Sulfuric acid (70%)	Unacceptable

### **Durability: alkalis**

Sodium hydroxide (10%)	Unacceptable
Sodium hydroxide (60%)	Unacceptable

### **Durability: fuels, oils and solvents**

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

### **Durability: alcohols, aldehydes, ketones**

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

### **Durability: halogens and gases**

Chlorine gas (dry)	Unacceptable
Fluorine (gas)	Unacceptable
O2 (oxygen gas)	Unacceptable
Sulfur dioxide (gas)	Acceptable

### **Durability: built environments**

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

### **Durability: flammability**

Flammability	Self-extinguishing
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### **Durability: thermal environments**

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

### **Primary material production: energy, CO2 and water**

Embodied energy, primary production	* 3.8	-	4.2	MJ/kg
CO2 footprint, primary production	* 0.181	-	0.2	kg/kg
Water usage	* 665	-	735	l/kg
Eco-indicator 99	127			millipoints/kg

### **Material processing: energy**

Coarse machining energy (per unit wt removed)	* 0.525	-	0.58	MJ/kg
Fine machining energy (per unit wt removed)	* 0.973	-	1.08	MJ/kg
Grinding energy (per unit wt removed)	* 1.47	-	1.63	MJ/kg

### **Material processing: CO2 footprint**

Coarse machining CO2 (per unit wt removed)	* 0.0394	-	0.0435	kg/kg
Fine machining CO2 (per unit wt removed)	* 0.073	-	0.0807	kg/kg
Grinding CO2 (per unit wt removed)	* 0.11	-	0.122	kg/kg

### **Material recycling: energy, CO2 and recycle fraction**

Recycle	✗			
Recycle fraction in current supply	0.1		%	
Downcycle	✓			
Combust for energy recovery	✓			
Heat of combustion (net)	* 19.8	-	21.3	MJ/kg
Combustion CO2	* 1.69	-	1.78	kg/kg
Landfill	✓			

Biodegrade	✓
Toxicity rating	Non-toxic
A renewable resource?	✓

#### Environmental notes

Cork is a renewable resource. Its processing generates waste: contaminated water and inflammable cork dust, but these can be managed.

## Supporting information

#### Design guidelines

The compressibility and great stability of cork, both in water and in oil, make it attractive for bottle stoppers, for gaskets and for packaging. It is easily cut and its fine cellular structure makes allows it to be carved to intricate shapes. Its vibration damping and thermal insulation qualities, together with its warm color and attractive texture give cork and products made from in (cork board, linoleum) a large market in floor, wall and ceiling coverings.

#### Technical notes

Cork is used for stoppers and bungs for bottles; floats; life-belts; walls; flooring; insulation; shoes; packaging; fancy goods; decoration; gaskets; road surfaces; linoleum; polishing; brake pads; vibration damping.

#### Typical uses

Corks; stoppers; bungs for bottles; floats; lifebelts; walls; flooring; insulation; shoes; packaging; fancy goods; decoration; gaskets; road surfaces; linoleum; polishing; brake pads; vibration damping.

## Links

Reference

ProcessUniverse

Producers