Oak (quercus rubra) (l)

General information

Designation

Quercus rubra (L)

Typical uses

Lumber; sleepers; mine timbers; fenceposts; veneer; pulpwood; fuelwood; flooring; furniture; general millwork; boxes; pallets & crates; agricultural implements; caskets; woodenware; handles; railroad cars;

Composition overview

Compositional summary

Cellulose/Hemicellulose/Lignin/12%H2O

Material family	Natural			
Base material	Wood (hardwood)			
Renewable content	100			%

Composition detail (polymers and natural materials)

Wood	100			%

Price

Price	* 2.01	-	2.68	USD/kg

Physical properties

Density	640	-	780	kg/m^3

Mechanical properties

Young's modulus	* 12.4	-	15.2	GPa
Yield strength (elastic limit)	* 46.5	-	56.8	MPa
Tensile strength	* 82.6	-	101	MPa
Elongation	* 1.79	-	2.19	% strain
Compressive strength	41.9	-	51.3	MPa
Flexural modulus	11.3	-	13.8	GPa
Flexural strength (modulus of rupture)	88.7	-	109	MPa
Shear modulus	* 0.92	-	1.12	GPa
Shear strength	11	-	13.5	MPa
Bulk modulus	* 1.08	-	1.2	GPa
Poisson's ratio	* 0.35	-	0.4	
Shape factor	5.3			
Hardness - Vickers	* 6.78	-	8.28	HV
Hardness - Brinell	* 45.4	-	55.4	MPa
Hardness - Janka	* 6.78	-	8.28	kN
Fatigue strength at 10^7 cycles	* 26.6	-	32.5	MPa

Mechanical loss coefficient (tan delta)	*	0.0067	-	0.0082	
Differential shrinkage (radial)		0.14	-	0.18	%
Differential shrinkage (tangential)		0.28	-	0.34	%
Radial shrinkage (green to oven-dry)		3.6	-	4.4	%
Tangential shrinkage (green to oven-dry)		7.7	-	9.5	%
Volumetric shrinkage (green to oven-dry)		12.3	-	15.1	%
Work to maximum strength		90	-	110	kJ/m^3

Impact & fracture properties

Fracture toughness	*	5.8	-	7.1	MPa.m^0.5

Thermal properties

Glass temperature		77	-	102	°C
Maximum service temperature		120	-	140	°C
Minimum service temperature	*	-73	-	-23	°C
Thermal conductivity	*	0.31	-	0.37	W/m.°C
Specific heat capacity		1.66e3	-	1.71e3	J/kg.°C
Thermal expansion coefficient	*	2	-	11	µstrain/°C

Electrical properties

Electrical resistivity		1.27e14	-	1.55e14	µohm.cm
Dielectric constant (relative permittivity)	*	6.95	-	8.5	
Dissipation factor (dielectric loss tangent)	*	0.082	-	0.1	
Dielectric strength (dielectric breakdown)	*	0.4	-	0.6	MV/m

Magnetic properties

Magnetic type	Non-magnetic

Optical properties

Transparency	Opaque

Durability

Water (fresh)	Limited use
Water (salt)	Limited use
Weak acids	Limited use
Strong acids	Unacceptable
Weak alkalis	Acceptable
Strong alkalis	Unacceptable
Organic solvents	Acceptable
Oxidation at 500C	Unacceptable
UV radiation (sunlight)	Good
Flammability	

	Highly flammable			

Primary production energy, CO2 and water

Embodied energy, primary production	11.6	-	12.8	MJ/kg

Sources

0.5 MJ/kg (Ximenes, 2006); 2 MJ/kg (Ximenes, 2006); 9.1 MJ/kg (Hammond and Jones, 2008); 11.6 MJ/kg (Hubbard and Bowe, 2010); 23.7 MJ/kg (Ecoinvent v2.2); 26 MJ/kg (Ecoinvent v2.2)

CO2 footprint, primary production	0.574	-	0.633	kg/kg

Sources

0.229 kg/kg (Ecoinvent v2.2); 0.412 kg/kg (Ecoinvent v2.2); 0.862 kg/kg (Hammond and Jones, 2008); 0.909 kg/kg (Hubbard and Bowe,

Water usage	* 665	-	735	l/kg

Processing energy, CO2 footprint & water

Coarse machining energy (per unit wt removed)	* 1.1	-	1.21	MJ/kg
Coarse machining CO2 (per unit wt removed)	* 0.0824	-	0.091	kg/kg
Fine machining energy (per unit wt removed)	* 6.71	-	7.41	MJ/kg
Fine machining CO2 (per unit wt removed)	* 0.503	-	0.556	kg/kg
Grinding energy (per unit wt removed)	* 12.9	-	14.3	MJ/kg
Grinding CO2 (per unit wt removed)	* 0.971	-	1.07	kg/kg

Recycling and end of life

Recycle	✗			
Recycle fraction in current supply	8.55	-	9.45	%
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	✓			

Notes

Warning

All woods have properties which show variation; they depend principally on growth conditions and moisture content.

Links

ProcessUniverse

Reference

Shape