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Improvement in the method for the impregnation of gypsum casts

Cast gypsum in the form of plaster of Paris casts and dies is particularly deficient in its mechanical properties [1–4]. A method reported to be effective in the enhancement of the properties of gypsum materials has been fully documented by Earnshaw [3, 4]. The method involved soaking the material in a liquid monomer to fill the void space and polymerizing *in situ* using thermal catalytic means. The reported new method [5] consists of an activated methyl methacrylate system that polymerizes in under 3 h and at ambient temperatures.

The specimens were prepared using an unmodified industrial plaster in various water–powder ratios and in various gang moulds (Table I). After casting the samples were removed and dried at 100° C for 24 h and were stored in a vacuum dessicator at room temperature prior to testing. The cast materials were immersed for approximately 1.5 h in a solution made up of methyl methacrylate (100 parts), lauroyl peroxide (4 parts) and N,N-dimethyl-p-toluidine (2 parts, wt/wt). When the temperature of the soak solution had risen to 60° C (about 90 min) the specimens were removed and allowed to stand at room temperatures for 30 min before testing.

Compressive, tensile and flexural strengths were determined using an Instron mechanical testing machine (Model TT(b)). Abrasion resistance was measured using a method similar to that reported by Mulhearn and Samuels [6]. Sample weight loss was recorded by abrading with a silicon carbide wheel under a 1 kg load for a period of 2 min. The results clearly demonstrate the enhancement in properties due to polymer impregnation and also the effects of varying the water–powder ratio (Table I).

TABLE I The effects of polymer impregnation on the properties of gypsum casts.

(a) Sample dimensions.

Test	Sample size
Compressive strength	25 mm o.d. × 45 mm.
Tensile strength	B.S. C.S.A. 25 mm × 25 mm.
Flexural strength	25 mm × 25 mm × 100 mm.
Abrasion resistance	25 mm × 25 mm × 25 mm.

(b) Compressive strength (N mm^{-2})

Water–powder ratio	Control	Impregnated	Strength factor
0.50	10.5	24.14	2.30
0.60	8.64	26.93	3.12
0.70	6.56	30.76	4.69
0.80	6.16	40.33	6.52

(c) Tensile strength (N mm^{-2})

Water–powder ratio	Control	Impregnated	Strength factor
0.50	1.10	5.76	5.23
0.60	0.99	6.40	6.47
0.70	0.76	6.72	8.84
0.80	0.60	6.16	10.26

TABLE I continued

(d) Flexural strength (N mm^{-2})

Water–powder ratio	Control	Impregnated	Strength factor
0.50	0.74	2.78	3.75
0.60	0.67	2.98	4.45
0.70	0.40	2.75	6.88
0.80	0.32	1.41	4.40

(e) Abrasion resistance % weight loss

Water–powder ratio	Control	Impregnated	Strength factor
0.50	6.4	0.9	7.1
0.60	8.6	1.1	7.8
0.70	9.2	1.7	5.4
0.80	9.3	1.9	4.9

(f) Polymer loadings

Water–powder ratio	% Polymer absorbed
0.50	21.9
0.60	28.3
0.70	35.4
0.80	41.7

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Correlations between oxygen transport phenomena in non-crystalline silica

The mobility of oxygen in fused silica is evident in a variety of phenomena such as permeation of O_2 gas, oxidation of silicon surfaces, and O_2/SiO_2 isotope exchange. However, a mechanistic relationship between all these processes has not yet been presented. The formation of amorphous silica scales during oxidation of silicon is known to be rate-controlled by permeation of molecular O_2 through the SiO_2 layer [1]. On the other hand, oxygen tracer diffusion coefficients as measured by isotopic exchange techniques are said to be uncorrelated to O_2 diffusion-controlled phenomena [2]. However, there should be a common underlying mechanism for the transport of oxygen because all the processes have uniformly low activation energies, depend linearly on the partial pressure of oxygen (p_{O_2}), as well as having algebraic relationships between their respective rate laws. All these observations can be understood if the transport of oxygen involves the interaction of O_2 molecules dissolved in SiO_2 with oxygen of the silica network (lattice oxygen).

Haul and Dümbgen [3] were the first to relate permeability of O_2 gas to diffusion coefficients measured by gas/solid isotope exchange. In their model interstitially dissolved O_2 acts as a defect by which lattice oxygen migrates. The diffusion of lattice oxygen (D_O) then, can be related to O_2 permeability (P_{O_2}),

$$P_{O_2} = D_{O_2} c_{O_2}/7.6 \qquad (1)$$

by

$$D_O = D_{O_2} c_{O_2}/c_O = 7.6 P_{O_2}/c_O \qquad (2)$$

where P_{O_2} is in units of cm^3 gas (STP) sec^{-1} for a 1 mm thick wall, 1 cm^2 area at 10 Torr gas pressure difference; D_{O_2} is the diffusion coefficient of molecular oxygen in cm^2 sec^{-1}; c_{O_2} and c_O are the concentrations of oxygen in units of cm^3 gas (STP) per cm^3 solid for dissolved O_2 and lattice oxygen in SiO_2 respectively.

The oxidation rate of silicon to silica (parabolic regime) is correlated with O_2 permeability [4], because the oxidation proceeds by diffusion of dissolved O_2 through the SiO_2 layer to the SiO_2/Si interface. Dankwerts [5] has shown that parabolic oxidation of surfaces can be described by a rate constant: