Development and Characterisation of Eggshell–Agar Biocomposites for Sustainable Interior Applications

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Abstract:

Eggshell waste represents a substantial waste stream, yet its valorisation in construction is dominated by use as a mineral filler in polymer or cement matrices whose binder remains petrochemical or clinker-based. This study investigates a bio-based alternative: waste eggshell powder bound in an agar–glycerol matrix.

The principal contribution is a reproducible production protocol. Shells are heat-treated at 120 °C, milled, and sieved to 150 µm. Agar is dissolved in a water–glycerol phase at 95 °C, then held at 80 °C under continuous stirring for 55 minutes, with the mineral fraction added incrementally near the end. The mixture is cast in silicone moulds, dried four days at ambient temperature, and consolidated for seven days. This addresses a known barrier in designer-led biofabrication, where absent shared procedures prevent reproduction.

Characterisation covers compression, three-point flexure, ignitability, and water absorption, with three specimens tested per formulation. Raising the mineral and agar fractions while reducing water increased mean compressive strength from 2.55 to 4.10 MPa. Halving the glycerol content shifted the material from unmeasurably ductile to a flexural strength of 2.33 MPa at a modulus of 192 MPa. Specimens self-extinguished four seconds after flame removal; shellac-coated specimens absorbed 0.7% of their mass over 24 hours of immersion.

Rather than interpreting low flexural stiffness solely as a material deficiency, the findings suggest that deformation capacity may represent an important resilience-related performance attribute for biomaterials. The study therefore proposes resilience rather than strength as the governing evaluation criterion for bio-based interior surfaces.

Keywords:

Eggshell waste, biocomposite, biofabrication protocol, material resilience, circular design.