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Response of Differently Structured Polymer-Based Composites to Increasingly Aggressive Aging

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Objectives It is hypothesized that the way polymer-based composites (composites) are structured and cured may have an impact on the way they respond to aging.

Methods A polymer-ceramic interpenetrating network material (Vita Enamic, VE), an industrially polymerized (Brillinat Crios ST, BC), and an in situ light-cured composite with discrete inorganic fillers (Admira Fusion5, AF5) were selected. A total of 308 parallelepiped shaped specimens ($18/2/2 \text{ mm}^3$) were either cut from CAD/CAM blocks (VE, BC) or condensed and cured in white POM molds. Specimens ($n=22$) were subjected to 4 different aging conditions: a) 24 h storage in distilled water at 37°C ; b) thermal cycling (TC) for 10,000 cycles $5/55^\circ\text{C}$; c) TC followed by storage in a 75% ethanol/water solution (EtOH) for 72h; and d) TC followed by an 3 week demineralization/remineralization cycling (DRC). CAD/CAM samples were also measured dry before the aging process. Three-point bending tests, quantitative and qualitative fractography, instrumented indentation tests (IIT), SEM and reliability analyzes were used. Uni- and multifactorial ANOVA, Tukey's post hoc test, and Weibull analysis was performed for statistical analysis.

Results A multifactorial analysis indicates a significant ($p<0.001$) and very strong effect of the material on the measured properties ($\eta P^2>0.9$). VE exhibited two to three times higher elastic moduli and hardness parameters compared to BC and AF5, which were comparable. Strength was highest in BC but was accompanied by high beam deformation. The effect of aging was comparatively smaller and was more evident in the IIT parameters, e.g. indentation modulus ($\eta P^2=0.574$), hardness (0.504), creep (0.341) than in the flexural strength (0.289) and modulus (0.170). Reliability was high ($m>15$) in VE, BC and regardless of aging protocol, while it was significantly reduced in AF5 following protocols b-d.

Conclusions Degradation occurred in all materials, which responded to the aggressive aging conditions with a deterioration in the measured properties of less than 10% compared to the initial situation.