Development of fracture tough dental materials containing ABA triblock copolymers for 3D printing applications

Yohann Catel,[1*] Pascal Fässler,[1] Iris Lamparth,[1] Sadini Omeragic,[1] Kai Rist,[1] Thomas Schnur[1]

[1]Ivoclar Vivadent AG, Bendererstrasse 2, 9494 Schaan, Principality of Liechtenstein

3D printing is an attractive technology in dentistry, as it enables a fast and cost-effective manufacturing of customized dental materials. Moreover, the possibility to print several objects at once represents a considerable advantage. DLP (digital light processing) and SLA (stereolithography) are the most commonly used 3D printing technologies in dentistry in order to produce with high precision various materials such as tooth models, orthodontic workpieces (e.g. splints), wax models for metal casting and press ceramics, denture bases and denture teeth. The development of 3D printing denture bases is particularly challenging as these materials must exhibit high mechanical properties (high flexural strength and modulus) as well as high fracture toughness. Due to the low reactivity and high volatility of MMA, conventional MMA-based denture bases are hardly suitable for 3D-printing. Therefore, 3D printing resins mainly contain dimethacrylates. Unfortunately, networks resulting from the curing of dimethacrylate mixtures are typically brittle and not adapted for the preparation of tough denture materials. There is therefore a need for an efficient toughening technology that would be compatible with the 3D printing process. The pioneering work of Bates *et al.* regarding the incorporation of block copolymers (BCPs) as toughening agents in epoxy resins represented a major breakthrough.[1] Indeed, this approach enables a significant increase in fracture toughness without strongly impairing the flexural modulus and the glass transition temperature of the cured epoxy resins. Although this toughening technology was shown to be efficient in epoxy materials, it just led to a moderate increase of toughness if applied in dimethacrylate networks.[2] One of the reasons that has been given to explain this phenomenon, is the inhomogeneity of the networks that are obtained via radical polymerization of di(meth)acrylates. In this contribution, a technology based on the toughening of low crosslink-density dimethacrylate networks using BCPs will be described.[3] In order to obtain materials exhibiting a moderate crosslink density, a combination of a urethane dimethacrylate with a monofunctional (meth)acrylate was selected as a monomer mixture. Various triblock copolymers were used as toughener. The addition of such BCPs to the monomer mixtures has been shown to result in the formation of nanostructures via self-assembly. The fracture toughness of the cured materials was significantly increased. Results regarding the influence of various factors (nature of the monomers and of the BCPs, BCP content, crosslink density, etc.) on both the mechanical properties and the fracture toughness will be presented.

References

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