Advancing Prosthodontics: Multi-Material 3D Printing for Durable Dentures

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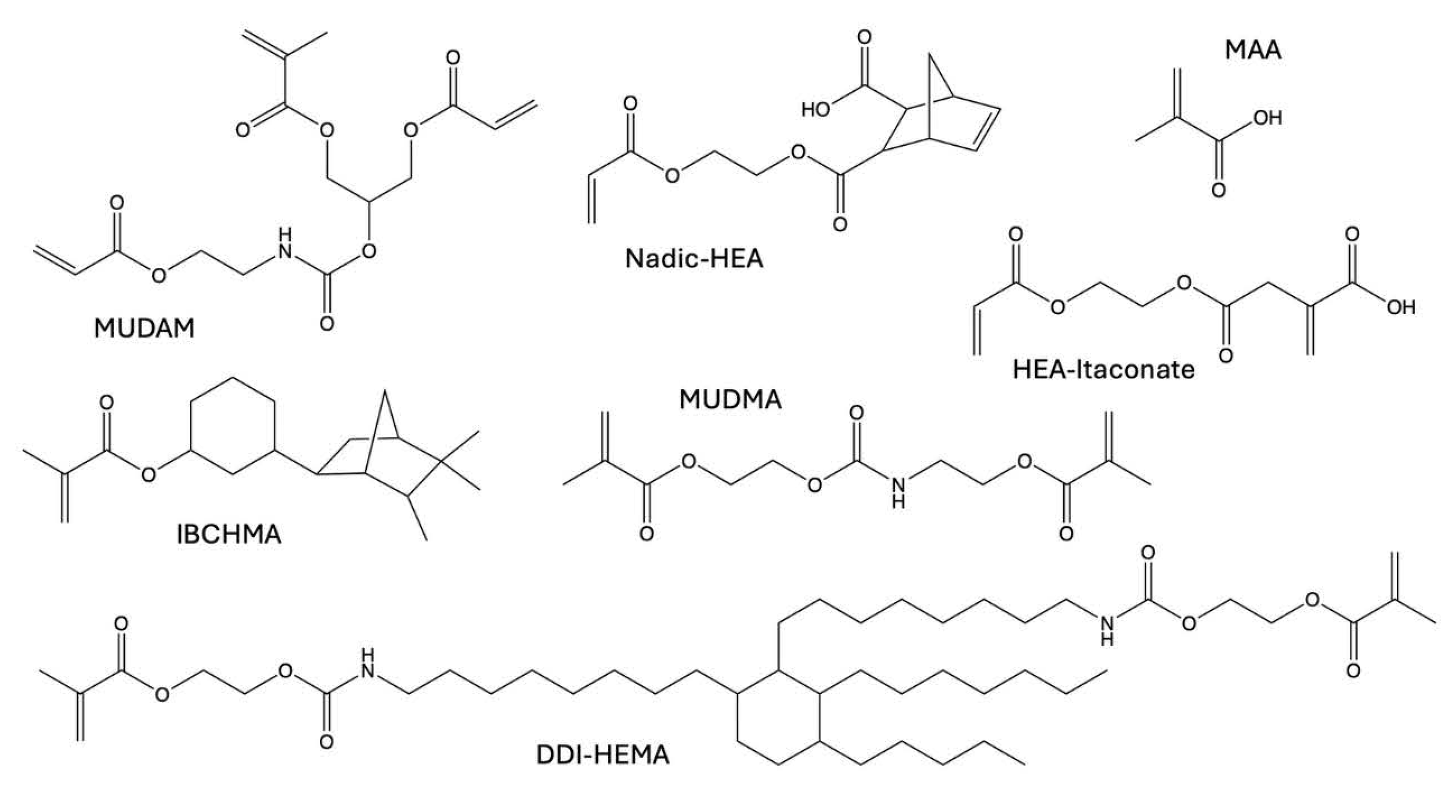
Introduction

Digital dentistry has driven interest in 3D-printed dentures, yet PMMA-based resins still suffer from low flexibility, poor fracture toughness, and minimum thickness requirements. We developed urethane-based resins with low to moderate viscosity, designed to improve mechanical properties via non-covalent interactions. These formulations are compatible with vat photopolymerization and multi-material inkjet printing, including ultra-low viscosity resins (<25 mPa·s), enabling efficient, high-performance denture fabrication.

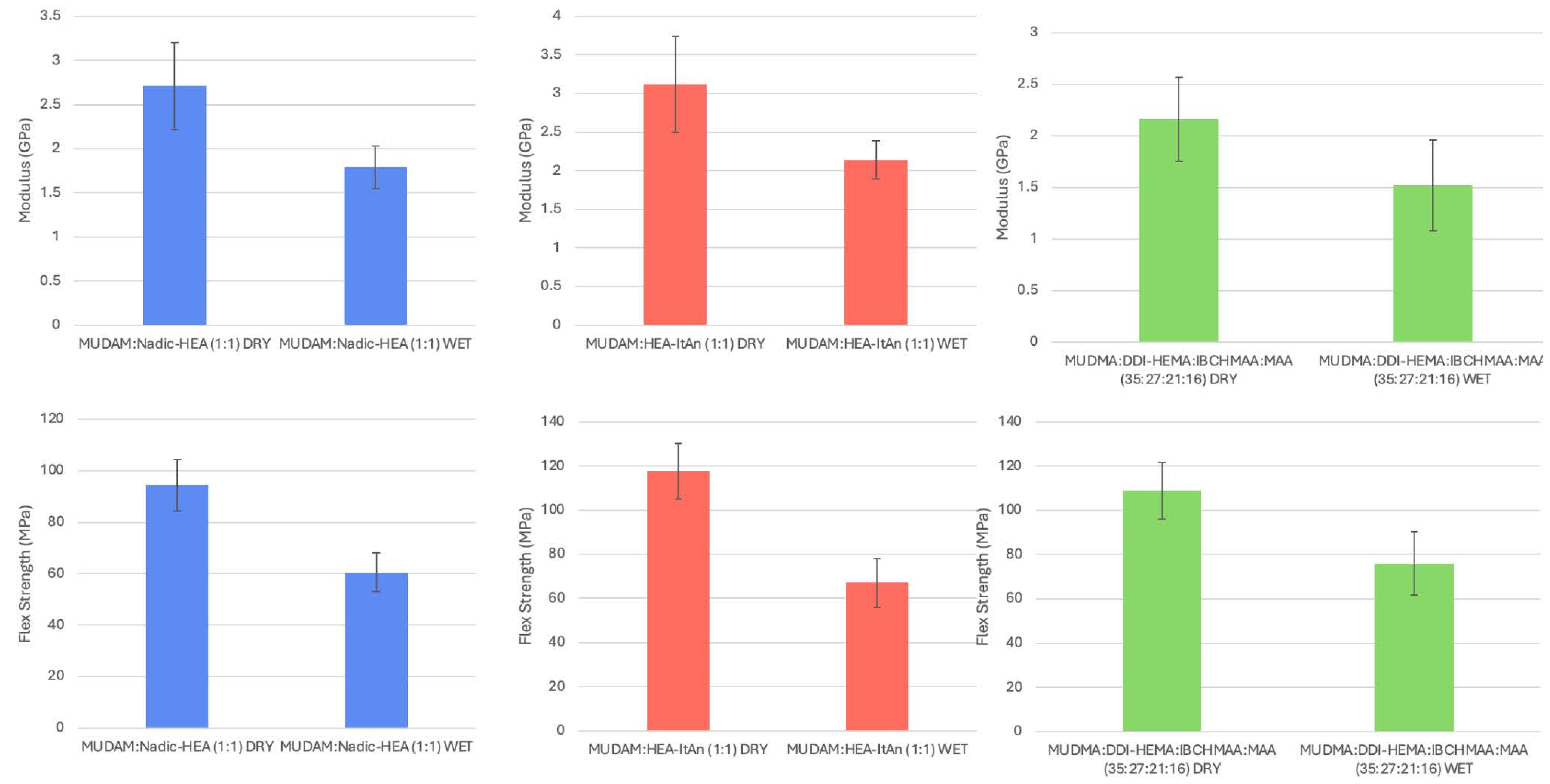
Methodology

Resins were synthesized using a 1:1 molar ratio of urethane to acid functional groups and monomers. Rectangular test bars (2×2×20 mm) were photopolymerized under 365 nm light, achieving 92% conversion (FT-IR). Post-curing was performed at 80 °C under dual 365/405 nm light. Mechanical testing included flexural strength, modulus, and toughness via three-point bending. Additional samples were immersed in 37 °C water for 48 hours to simulate oral conditions.

Materials



Results

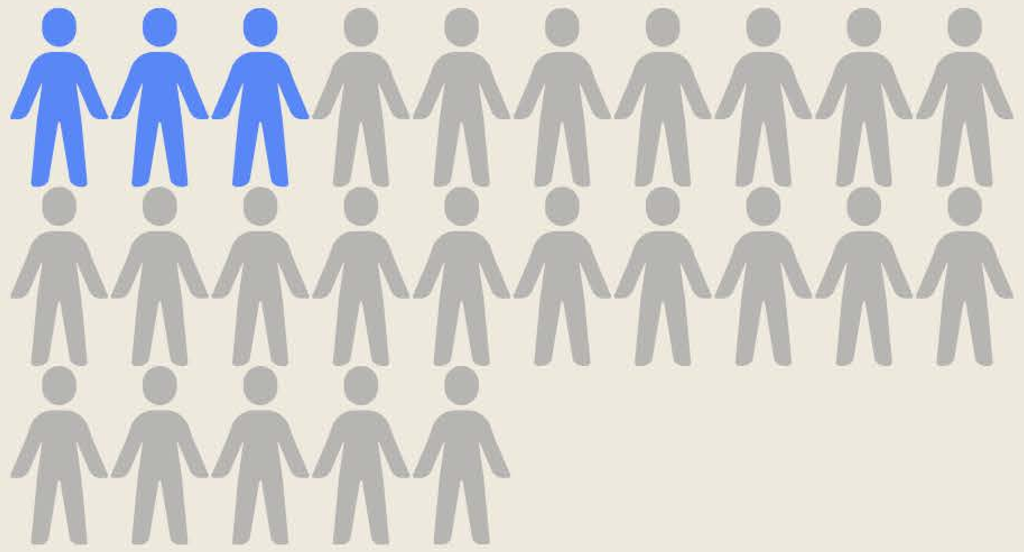


	Modulus (GPa)	Flexural Strength (MPa)
MUDAM:Nadic-HEA (1:1) DRY	2.71 (0.49)	94.40 (10.05)
MUDAM:Nadic-HEA (1:1) WET	1.79 (0.24)	60.53 (7.50)
MUDAM:HEA-ItAn (1:1) DRY	3.12 (0.62)	117.73 (12.62)
MUDAM:HEA-ItAn (1:1) WET	2.14 (0.25)	67.05 (11.13)
MUDMA:DDI-HEMA:IBCHMAA:MAA (35:27:21:16) DRY	2.16 (0.41)	108.99 (12.83)
MUDMA:DDI-HEMA:IBCHMAA:MAA (35:27:21:16) WET	1.52 (0.44)	76.01 (14.52)

Purpose and Clinical Implications

Over 44 million Americans rely on dentures. Poor oral health in edentulous populations is linked to over 60 systemic conditions, including diabetes and cardiovascular disease. Our goal is to develop denture materials that are both cost-effective and superior to PMMA in performance.

We are also exploring the integration of light-activated antimicrobial compounds to enhance infection resistance. The final goal of our research is a prosthetic that is not only stronger, but actively resists infection.



Conclusion

Urethane-based resins offer improved strength, flexibility, and printability. Their compatibility with advanced printing methods supports better clinical outcomes and broader accessibility. Ongoing research will focus on optimizing durability in moist oral environments.