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Plasma-Assisted Bifunctionalization of Glass Fillers to Develop Contact-Active Antibacterial Dental Composites

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INTRODUCTION & AIM

Secondary caries accounts for up to 60% of composite restoration failures, driven by bacterial biofilm accumulation at the tooth-restoration interface. Functional surface engineering, as showing in Fig 1, of glass filler particles with dimethyloctadecyl[3-(trimethoxysilyl)propyl]ammonium chloride (QASi-18) and 3-(methacryloxy)propyltrimethoxysilane (MPS) enables simultaneous contact-active antimicrobial function and chemical bonding between filler and resin matrix. Wet chemical silanization is the conventional functionalization route; plasma treatment emerges as an alternative offering stable, homogeneous surface modification. This study compares both routes regarding interfacial stability, mechanical performance, and antimicrobial efficacy (ASTM E2149-10) against *Streptococcus salivarius, Escherichia coli* and *Candida albicans.*

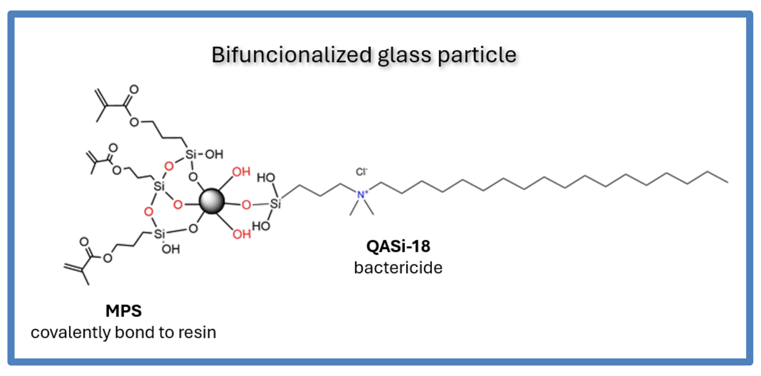
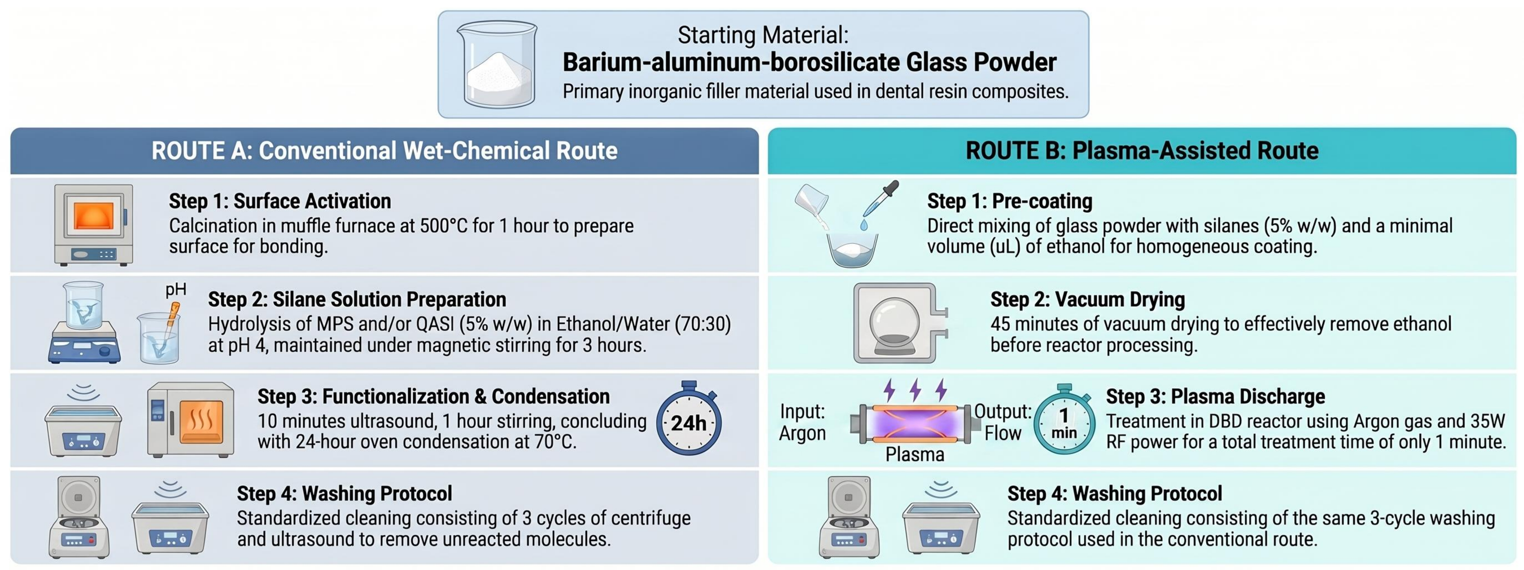
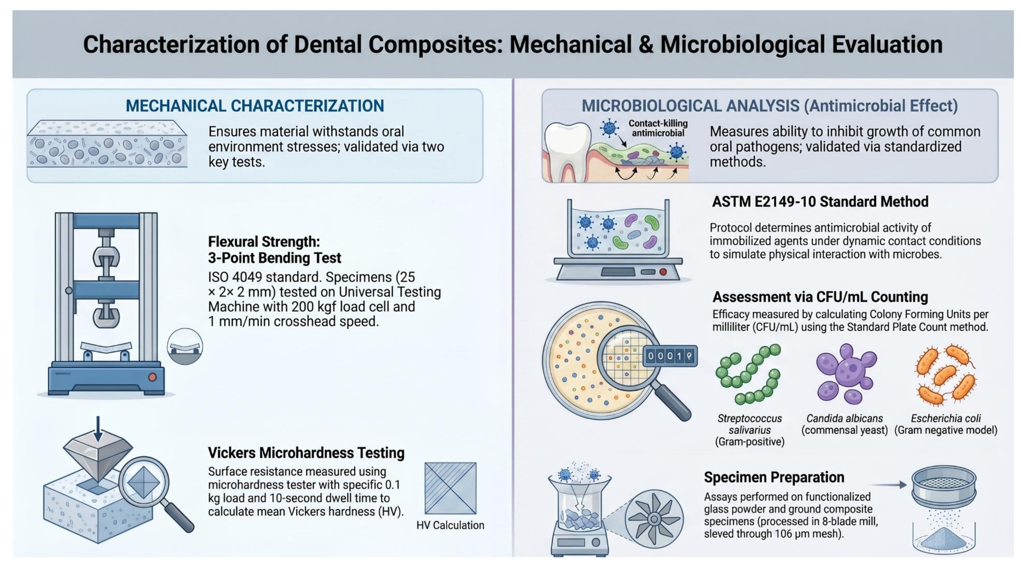


Fig. 1 - Bifunctionalized glass filler particle co-grafted with MPS and QASi-18 via siloxane linkages.

METHOD





The schematic figures were developed by the assistance of NotebookLM.

RESULTS & DISCUSSION

Fig. 2 - Tukey's test comparison for composites containing 60 wt% functionalized glass powder. Different letters indicate significant differences (ANOVA, p<0.05).

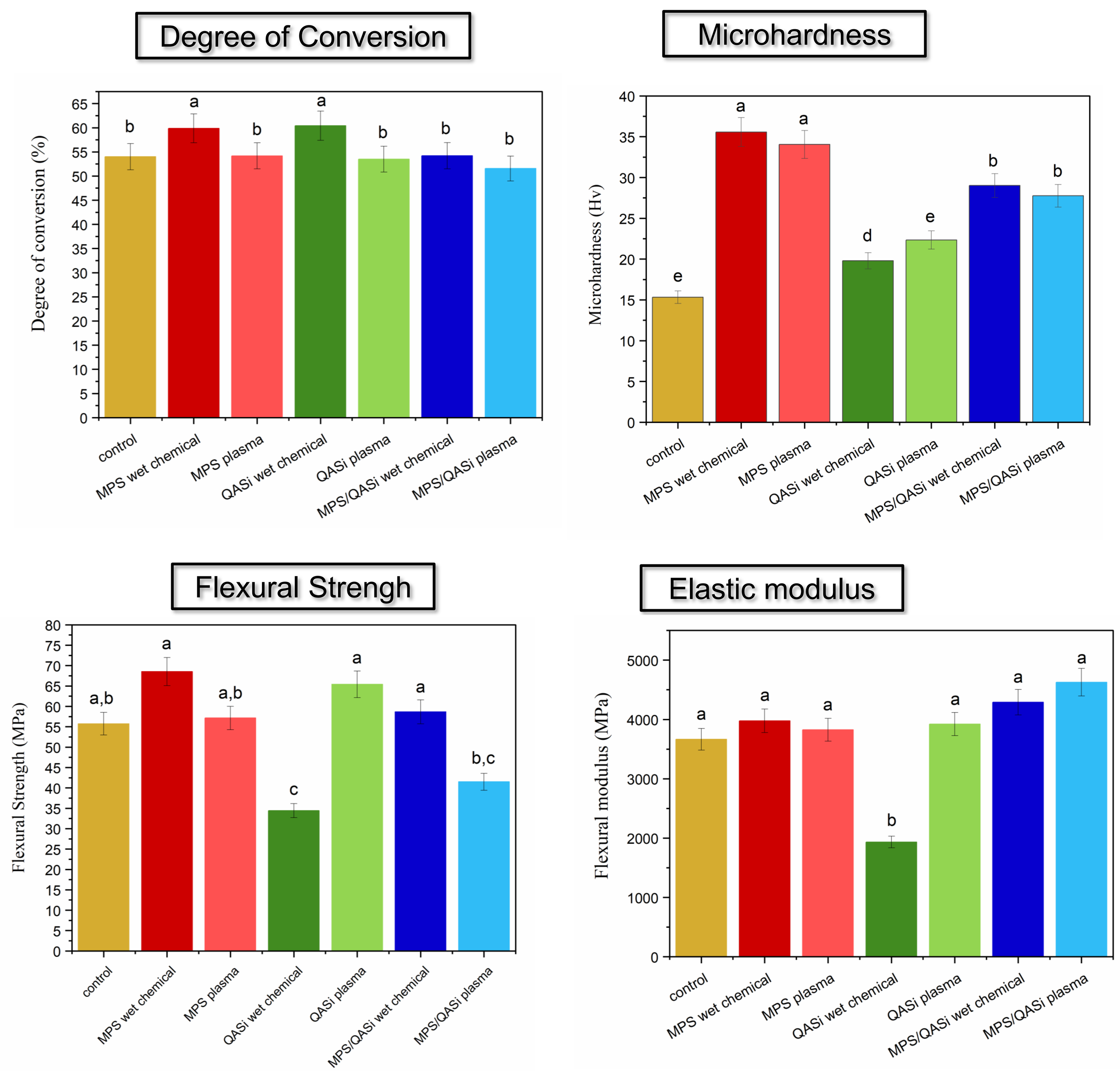


Fig. 3 - Zeta Potential of glass powder functionalized via wet-chemistry and plasma routes, suspended in ethanol (0.093 g/L) after 5 min sonication and SEM images of cryogenic fracture surfaces of dental composites containing 60 wt% functionalized glass powder via wet-chemistry and plasma routes.

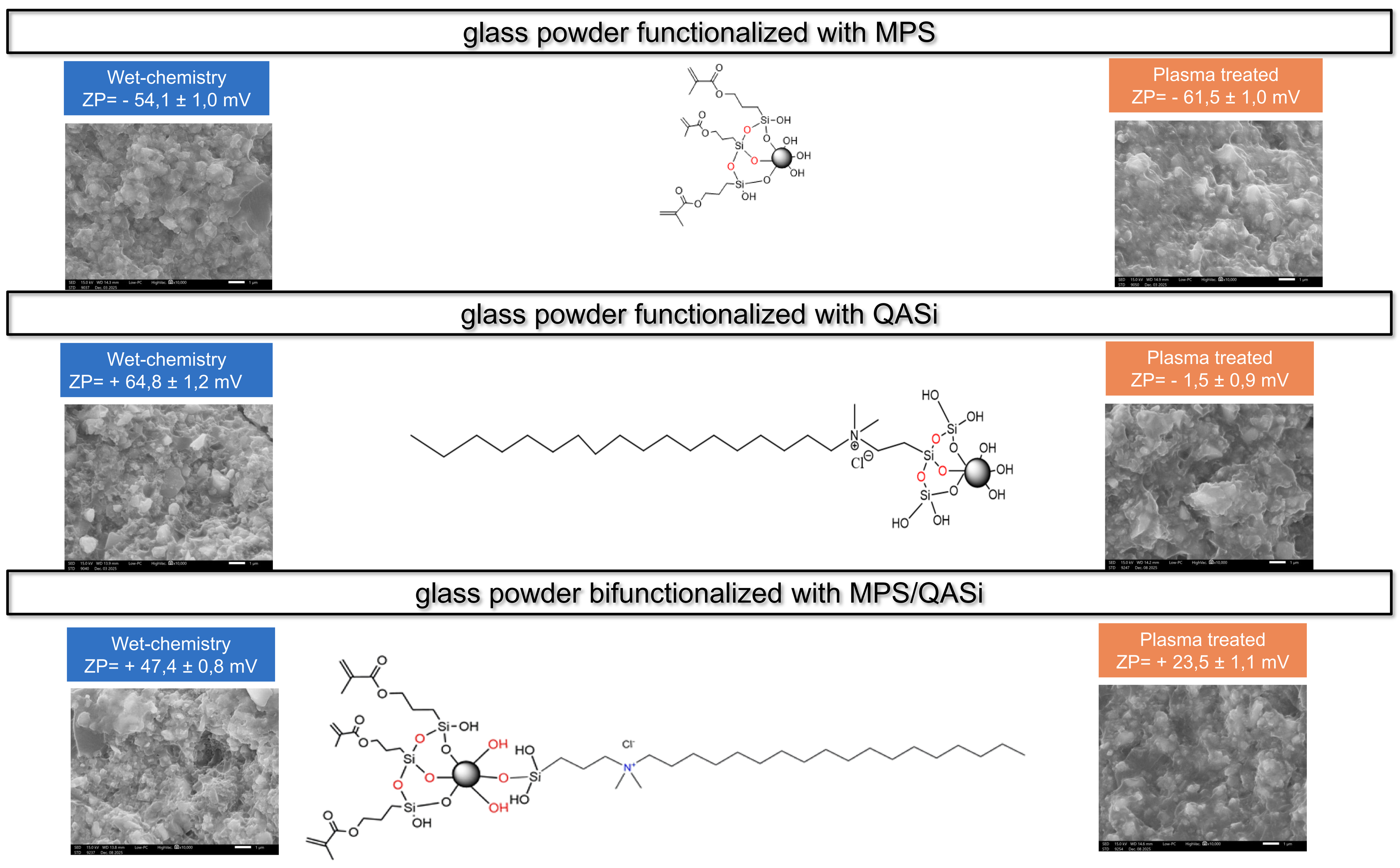
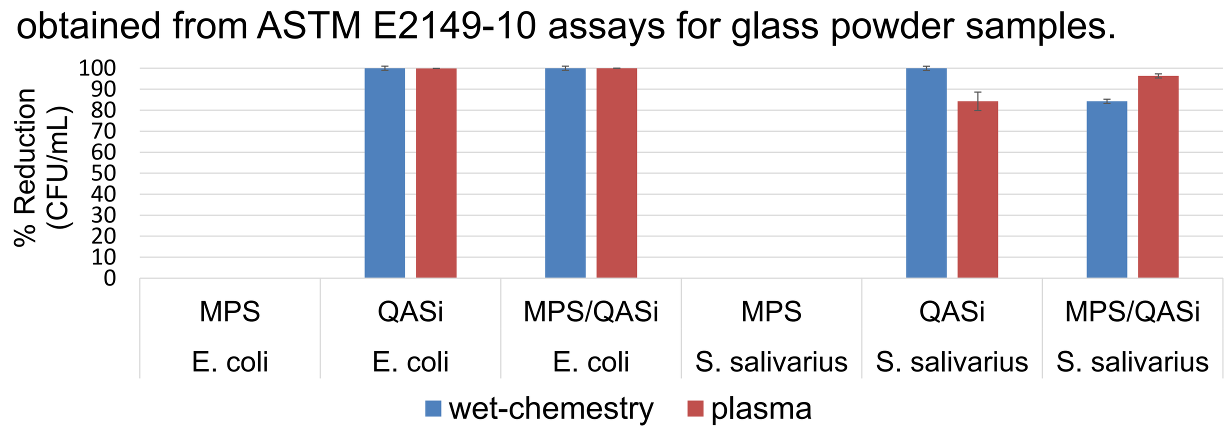


Fig. 4 - CFU/mL reduction (%) for *Candida albicans*, *Escherichia coli*, and *Streptococcus salivarius* obtained from ASTM E2149-10 assays for glass powder samples.



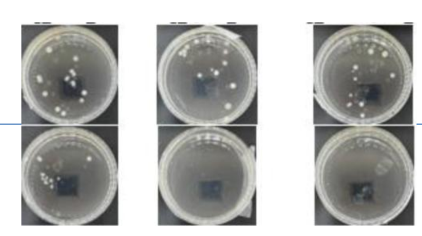
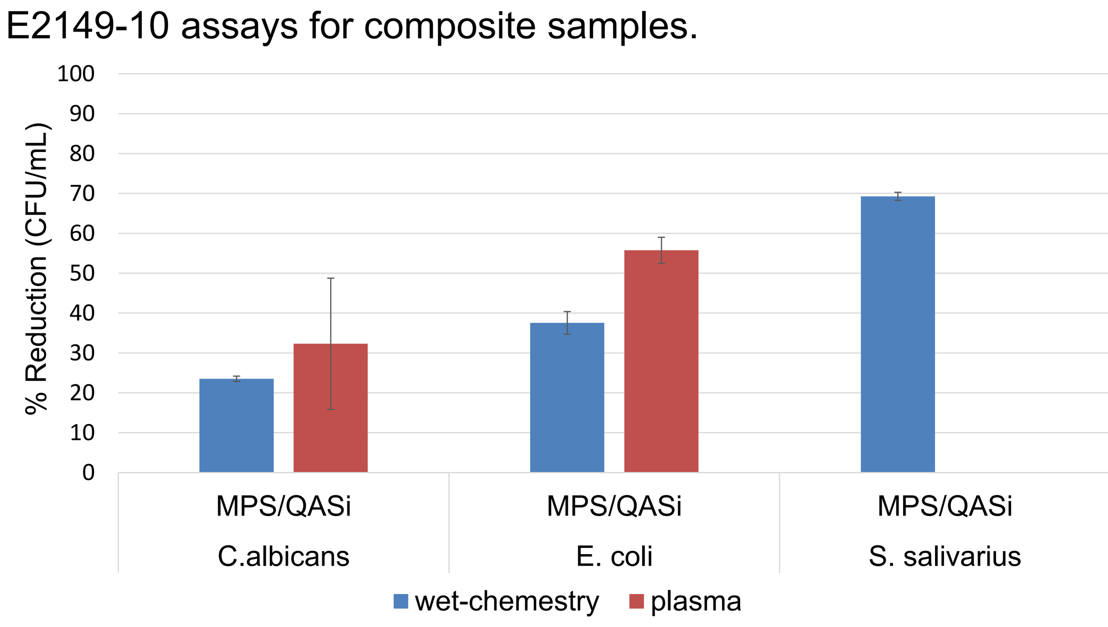


Fig. 5 - CFU/mL reduction (%) for *Candida albicans*, *Escherichia coli*, and *Streptococcus salivarius* obtained from ASTM E2149-10 assays for composite samples.



CONCLUSIONS

Plasma bifunctionalization of glass powder with MPS and QASi-18 yielded composites with confirmed contact-active antimicrobial efficacy and preserved mechanical properties. The plasma route performed comparably or superior to wet-chemistry across all tested microorganisms, while eliminating thermal pre-treatment and reduce use of organic solvents, establishing it as a process-efficient alternative for secondary caries-resistant restorations.

REFERENCES

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