Investigation of indentation size effect and R-curve behaviour of $Li_2O–SiO_2$ and $Li_2O–2SiO_2$ glass ceramics

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ABSTRACT

Indentation size effect (ISE) and R-curve behaviour of $Li_2O–SiO_2$ and $Li_2O–2SiO_2$ glass ceramics are investigated using micro-indentation and indentation-strength (IS) techniques, respectively. Vickers micro-indentations were applied on both materials at the load of 0.10–19.6 N to determine the load influence on the measured hardness. For the IS-measured fracture toughness, the load ranged from 1.96 to 19.6 N. The hardness decreased with increasing load by 20% and 18% on $Li_2O–SiO_2$ and $Li_2O–2SiO_2$ glass ceramics, respectively, indicating the ISE behaviour on both materials. The fracture toughness increased with the load by 27% and 59% on $Li_2O–SiO_2$ and $Li_2O–2SiO_2$ glass ceramics, respectively, signifying the R-curve behaviour. The ISE behaviour of both materials was analysed using the Meyer's, Hays–Kendall (HK), proportional specimen resistance (PSR), Nix–Gao (NG), modified PSR (MPSR) and elastic plastic deformation (EPD) models while the R-curve behaviour was analysed by the fractional power law. The Meyer's index of both materials was less than 2, strongly confirming the ISE existence. The HK, PSR and NG models were only suitable to determine intrinsic Vickers hardness for $Li_2O–2SiO_2$ glass ceramic while the MPSR and EPD models were successful for both materials. The fractional power law gave higher R-curve steepness for $Li_2O–2SiO_2$ than $Li_2O–SiO_2$ glass ceramics. Also, material and brittleness indices predicted, respectively, higher quasi-plasticity and better machinability for $Li_2O–2SiO_2$ than $Li_2O–SiO_2$ glass ceramics indicating superior performance in the former to the latter. Finally, this study presents a new significant insight into the micro-mechanisms of fracture tolerance behaviour of these glass ceramics which is critical to their functional performance as structural ceramics.

KEYWORDS

Indentation size effect; Indentation techniques; $Li_2O–SiO_2$/$Li_2O–2SiO_2$ glass ceramics; Mechanical properties; R-curve behaviour

ACKNOWLEDGMENTS

The funding support by the Universit Teknologi Brunei (UTB) Internal Research Grant (UTB/GSR/2/2021(11)) is greatly acknowledged.