Topological Dependence of Chemical Durability in Densified Glasses

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Glasses gradually dissolve and corrode when they are exposed to aqueous solutions, and for many applications it is necessary to understand and predict the kinetics of the glass dissolution. Recent studies have indicated that the dissolution rate of oxide glasses with different chemical compositions is controlled by their atomic topology. That is, the dissolution rate exponentially decreases with the number of topological constraints per atom acting within the molecular network. Here, to further understand the topological origin of chemical durability, we study the effect of permanent densification on dissolution kinetics. Specifically, we study the bulk glass dissolution rate of phosphate, silicophosphate, borophosphate, borosilicate, and aluminoborosilicate glasses, which have been compressed at 0.5, 1.0, and 2.0 GPa at the glass transition temperature. We perform weight loss and supplementary modifier leaching measurements of bulk samples immersed in acid (pH 2) and neutral (pH 7) solutions. Compression generally improves the chemical durability as measured from weight loss, but the effect is highly composition- and pressure-dependent. As such, we show that the dissolution mechanisms depend on the topological changes induced by permanent densification, which in turn are a function of the changes in the number of nonbridging oxygens and the network cross-linking.