Public Executive Summary:

The goal in hydrofracturing and stimulation of gas and oil wells is maintaining high permeability paths for resource recovery over the life of the well. This is commonly achieved by introducing a slurry of surfactants, corrosives, and ceramic aggregates into the fractures emanating from the well bore after the hydrofracturing process. The aggregates are then pinned by closure stresses after the well pressure has been relieved, and "prop" the fracture open, thereby providing a permeable pathway for oil and gas to migrate to the well bore for subsequent extraction. Hence, the aggregates are commonly referred to in the industry as proppants.

Several key properties that govern the effectiveness of a propping agent include specific gravity, strength, elastic modulus (stiffness), and hardness. Low specific gravity is desirable in order to enhance placement of the proppants without excessive gravitational migration, thereby permitting use of lower cost fracture fluids and reduced burden on pumping equipment. High strengths are desirable to prevent blinding of the proppant pack by fracture and comminution under the high closure stresses experienced in deep wells. Hardness and elastic modulus must match the surrounding geologic formation to prevent impaction of the proppant into softer strata, thereby prolonging permeability of the hydrofractured zone.

A wide range of proppant materials have been employed over the years including walnut hulls, Brady and Ottawa sands, glass, and fused zircon. State of the art proppants are derived from sintered aluminosilicates, such as kaolin and bauxite. However, the demand for high alumina content aluminosilicates for primary aluminum metal production and for use in industrial refractories has increased nearly six-fold worldwide in the past three years, resulting in a significant shortage, accompanied by a concomitant increase in cost and availability of high strength proppants.

Research at Penn State addresses the use of alternative raw materials for manufacturing high quality proppants. Proppants derived from chemically bonded pozzolonic materials (flyash and slags), mixed glass cullet, single- and double- ion exchanged glass beads, doped low-grade alumina-bearing ores, and rhyolite based glass-ceramics have been developed which rival commercially available sintered bauxite based materials with regard to strength, hardness, specific gravity and behavior in American Petroleum Institute testing (API-60 and 61).

This proposal addresses extension of prior work to a raw material derived from an industrial/domestic waste stream (mixed glass cullet) which is indigenous to regions where significant growth in demand for proppants is anticipated in the future, such as in the development of the Marcellus and Devonian shales for natural gas production.