Thermal protection systems, which are commonly used to protect spacecraft during atmospheric entry, have traditionally been made of materials which are traditionally high in manufacturing costs for both the materials needed and the manufacturing complexity, such as carbon-carbon composites and aerogels. The limitations of polymer reinforced composites have limited their entry into these applications, except for pyrolyzed composite materials, such as carbon-carbon and ceramic composites. These materials have been successfully demonstrated their utility in extreme environments, such as spacecraft heat shields, but their high costs and the difficulty to manufacture them have limited their use to similarly high performance applications where the costs are justifiable.

Previous work by others with “fuzzy fiber” composites have shown that aligned carbon nanotubes (CNTs) grown on fibers can improve their thermal conductivity and wettability. To this end vertically aligned CNTs were studied for their potential use, but found to be difficult to process with current conventional techniques. A composite material comprised of basalt, a relatively new reinforcing fiber, and phenolic, which has been used in high-temperature applications with great success was made to attempt to create a new material for these applications. To further improve upon the favorable properties of the resulting composite, the composite was pyrolyzed to produce a basalt-carbon composite with a higher thermal stability than its pristine state. While testing the effects of pyrolysis on the thermal stability, a novel technique was also developed to promote in-situ carbon nanotube growth of the resulting basalt-carbon composite without using a monolithic piece of cured phenolic resin in place of the standard aromatic hydrocarbon-catalyst precursor. The in-situ growth of carbon nanotubes (CNTs) was explored as their thermal stability and effectiveness in improving performance has been previously demonstrated when used as a resin additive [4]. The specimens were examined for morphology and thermogravimetric behavior to determine the effects of both pyrolysis and CNT growth during pyrolysis of the basalt phenolic composites.