ABSTRACT

High-temperature performance cyanate ester composites with carboranes

Shailja Goyal,[1] Michael Forrester,[1] Scott Carnahan,[2] Mark W Lee,[4] Sabrina Torres,[3] Danielle Coverdell,[3] Aaron Rossini,[2] Eric Cochran[1]

[1]Chemical and Biological Engineering Department, Iowa State University, Ames, Iowa 50011, USA

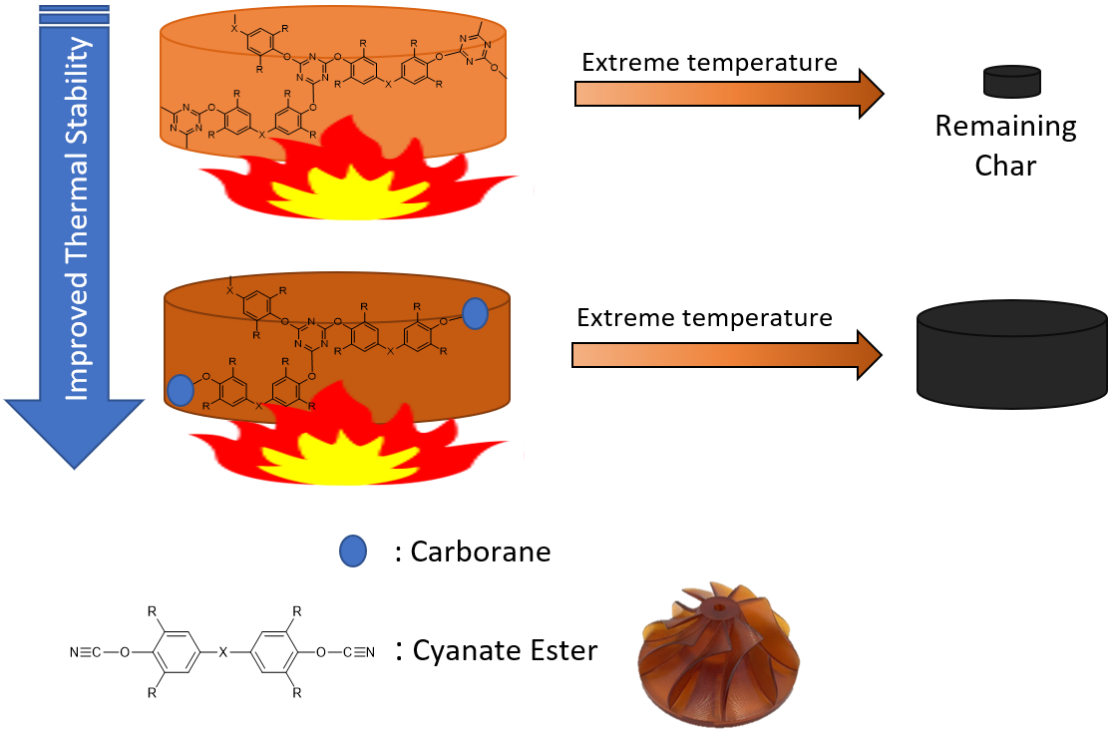
[2]Department of Chemistry, Iowa State University, Ames, IA, 50011, USA

[3]Kansas City National Security Campus, 14520 Botts Road, Kansas City, Missouri 64147, USA

[4]Department of Chemistry, University of Missouri-Columbia 65211, USA

Cyanate ester (CE) is an important class of materials among high-temperature performance thermosets due to their high glass transition temperatures (>220°C), excellent thermal stability, and low flammability. In this work, we demonstrate carborane-filled cyanate ester (CE) nanocomposites that have an exceptionally high oxidative thermal stability as compared to the pristine resin. Carborane fillers were solvent blended at various mass loadings in the resin and cured to study their effect on thermal properties. Our TGA experiments show that the ultimate char yield of the resin can be increased from 0% to as high as 76 and 82.1% with 30 wt.% PD and EP carborane loading respectively at 1000◦C in air. We interrogated the degradation mechanism of these carborane-CE composites through FTIR, Elemental Analysis, TGA-Mass Spectroscopy (TGA-MS), and solid-state ^{11}B and ^{12}C NMR. We have discovered that the iminocarbonate and oxazolidinone linkages between CE and carboranes are labile, producing a moderate temperature (ca. 450 ◦C) initial degradation in TGA. Howbeit, at higher temperatures (> 650◦C) the carborane structure disintegrates and is oxidized to boronic acid and boroxine structures.

In further studies, we are now working to translate these mechanistic insights to design other thermally protected thermoset matrices such as epoxies. Additionally, we are elucidating the effect of boron-based fillers on mechanical properties.



: Carborane

: Cyanate Ester