

Industry Day Theme # Emerging Nano and Advanced Materials (ENA)

Sustainable approach to thermal enhancement of bio-based polybenzoxazines

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Abstract

The present work demonstrate a sustainable approach to improve thermal performance of bio-based polybenzoxazines via hybridising with inorganic functionality following structural modification as well as additive approach. Monomers were structurally modified with silane functionality, which on polymerization generates silica in situ. In addition, functionalised silica has also been prepared to improve the thermal performance of the resulting polybenzoxazine composites.

Introduction

Polybenzoxazines emerging as a new class of phenolics, are one of the rarely existing high performance materials that satisfy all the performance requirements for structural composites and advance aerospace applications. Benzoxazines are relatively inexpensive materials and exhibit interesting properties such as negligible curing shrinkage, significantly low water absorption, high glass transition temperatures and rapidly develop their mechanical and thermal properties with the progress of polymerization. In addition to this, molecular designing flexibility in benzoxazines which is possible through the astute choice of amine and phenolic components bestow an extremely interesting feature to these materials in terms of tunability, thereby opening up new vistas of application. In view of the environmental concerns, a lot of attention has been directed towards the exploration of bio-based raw materials, which can have potential to act as an effective substitute for petro-based chemicals. Bio-based benzoxazines offers processing advantages and economic benefits, however, suffers from drawbacks such as low crosslink density and char yield, which subsequently leads to inferior thermal stability relative to petro based analogues.

Methodology

1. Reactive Approach: Structural Modification of benzoxazine monomers with silane functionality to prepare hybrid polybenzoxazine-silica.
2. Additive Approach: Fabrication of polybenzoxazine composites with functionalized silica to improve thermal performance.

Conclusions

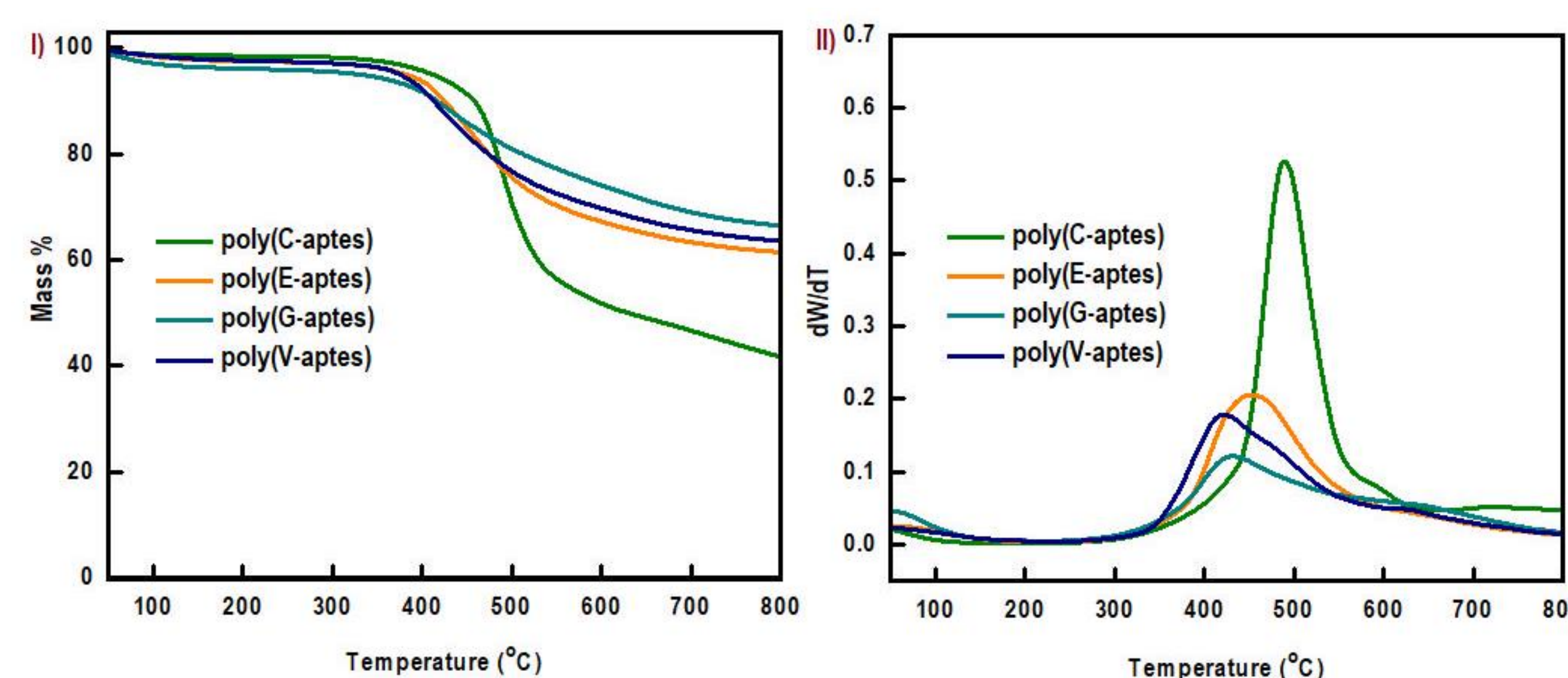
- Benzoxazine monomer functionalized with silane undergoes polymerization to yield polybenzoxazine network integrated with three dimensional framework of silica linkages. Silica generated in situ is credited for the improved thermal stability and high char yield.
- Polybenzoxazine composites developed using functionalized silica shows relatively improved thermal performance than the non-functionalized fillers which is credited to the improved dispersion of the filler throughout the material.

Industrial Significance

- Bio-based silanes can be employed to improve the thermal performance of the polybenzoxazine materials.
- Functionalised silica particles shows improved dispersion and can be used to fabricate composites with improved thermal and mechanical performance in view of the better interaction with the matrix.

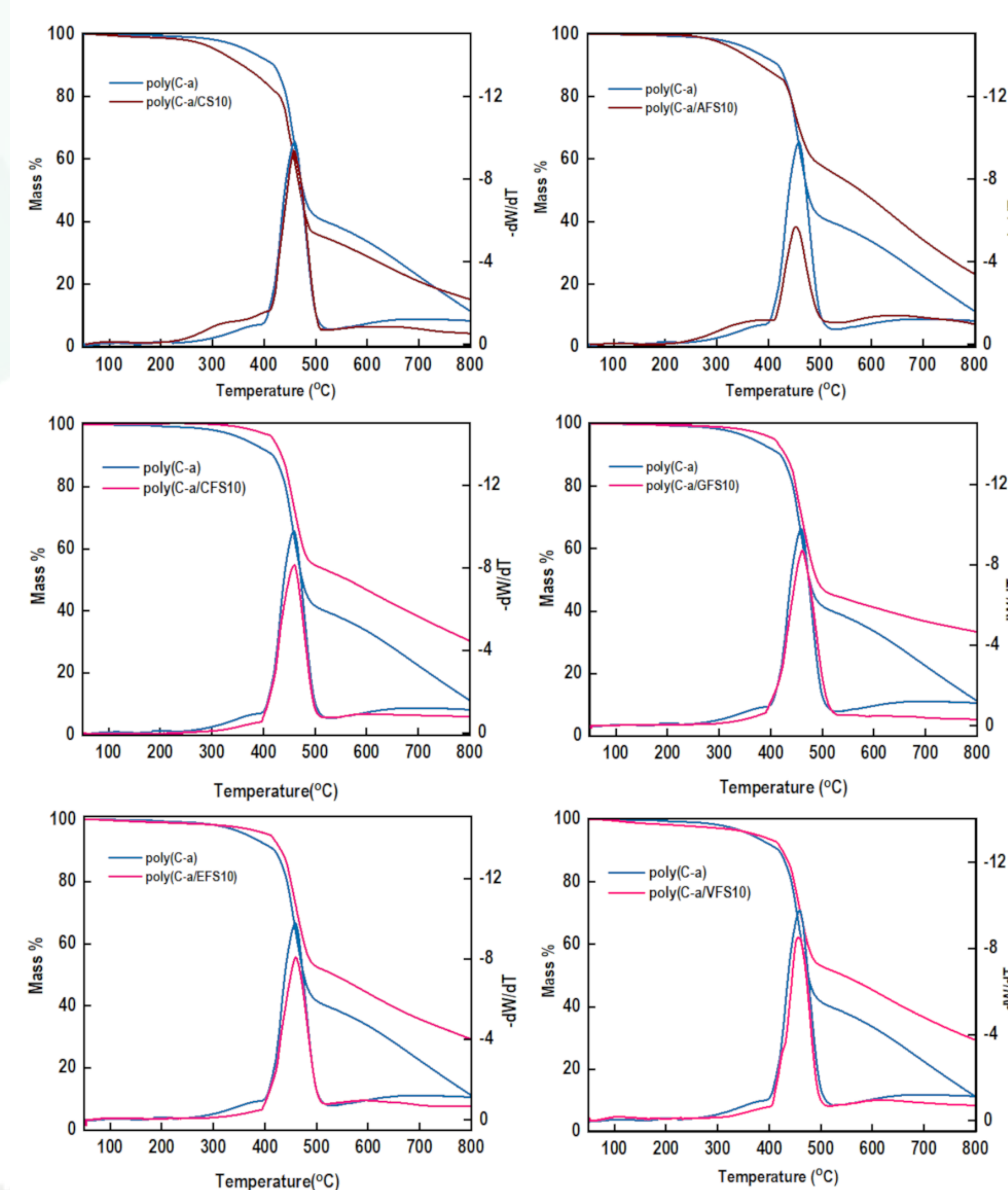
Results

1. Reactive Approach



Thermal degradation behavior of cured i) cardanol based polybenzoxazine: poly(C-aptcs), ii) guaiacol based polybenzoxazine poly(G-aptcs), iii) eugenol based polybenzoxazine poly(E-aptcs) and iv) vanillin based polybenzoxazine poly(V-aptcs) under nitrogen atmosphere.

2. Additive Approach



TGA traces of cured polybenzoxazine composites prepared using Cardanol-aniline (C-a) resin formulated with control silica, Amine functionalised silica (AFS15) and benzoxazine functionalized silica (CFS, GFS, EFS and VFS) under nitrogen atmosphere.

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References

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