年度工作进展
2020

浙大宁波理工学院
高分子共混与复合改性研究室

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新增项目

- 国家自然科学基金面上项目 1 项
  - 张艳：生物基核-壳膨胀阻燃剂/氧化石墨烯的杂化结构设计及其阻燃增韧聚乳酸的作用机理研究，2021.1-2024.12, 59万元
- 浙江省基础公益研究计划工业项目1 项
  - 郭正虹：新能源汽车装饰材料用无卤阻燃PC/ABS 合金，2021.1-2023.12，10+100万元
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- 横向项目 1 项
  - 郭正虹：高效阻燃聚酯纤维的研发，宁波华星科技有限公司， 2020.12.1-2023.12.1, 300万元

在研项目

- 国家自然科学基金 **3** 项
  - 方征平等：高分子材料燃烧过程的抑烟减毒新原理与新方法，**2020.01-2024.12**，**299.5** 万元
  - 方征平：富勒烯在聚乙烯**/**金属氢氧化物复合材料中的协同阻燃作用研究，**2017.01-2020.12**，**62** 万元
  - 冉诗雅：具有自由基捕获能力的三氟甲烷磺酸稀土盐阻燃聚乙烯，**2018.01-2020.12**，**23** 万元
- 浙江省自然科学基金 **2** 项
  - 张艳：生物基氧化石墨烯复合膨胀型阻燃剂的设计制备及其改性聚乳酸的性能研究，**2020.1-2022.12**，**9** 万元
  - 闫红强：低温固化生物基苯并噁嗪树脂的构筑及其多功能化，**2019.1-2021.12**，**9** 万元

- 宁波市工业重大专项（科技创新团队）**1** 项
  - 方征平：先进阻燃高分子材料研发（准备验收）
- 宁波市自然科学基金 **2** 项
  - 郭正虹：苯基膦酸稀土晶体“多层次协同阻燃”机理研究，**2018.12-2020.12**，**3** 万元
  - 冉诗雅：具有自由基捕获能力的稀土化合物对聚烯烃热稳定性和阻燃性能的影响，**2018.12-2020.12**，**3** 万元
- 宁波市公益类科技计划项目 **1** 项
  - 冉诗雅：三氨基三蝶烯-植酸多孔阻燃剂的制备及其对真实居民火灾的影响，**2018.11-2021.10**，**10** 万元

- 浙江大学宁波校区平台项目 **1** 项
  - 方征平、程捷：宁波烯烃聚合物先进制造技术创新示范平台建设（一期），**2019.12.20-2012.12.19**，**2000** 万元
- 横向项目 **5** 项
  - 张艳：用于血红蛋白分离的交联型聚酯的研究开发，**2019.10.22-2020.1.22**，宁波艾捷康宁生物科技有限公司，**5** 万元
  - 张艳：浴缸用亚克力板材的改性研究及制备，**2019.11.28-2020.12.28**，宁波沃腾玛尔洁具有限公司，**5** 万元
  - 郭正虹：普利特公司新能源汽车用阻燃材料，**2019.1.1-2020.12.31**，浙江普利特新材料有限公司，**15** 万
  - 郭正虹：高流动性**ABS**树脂的研发，**2019.10.30-2021.1.30**，宁波市荣欣祥塑胶有限公司，**30** 万
  - 郭正虹：表面光洁聚苯乙烯的开发. **2019.12.1-2020.12.31**，宁波冠德新材料有限公司，**20**万

论文

- 中国百篇最具影响国际学术论文

  Fang F, Ran SY*, Fang ZP, Song PA*, Wang H. Improved flame resistance and thermo-mechanical properties of epoxy resin nanocomposites from functionalized graphene oxide via self-assembly in water, Composites B, 2019.5, 165: 406-416

76. 论文题目：Improved flame resistance and thermo-mechanical properties of epoxy resin nanocomposites from functionalized graphene oxide via self-assembly in water

作 者：Fang, Fang; Ran, Shiya; Fang, Zhengping; Song, Pingan; Wang, Hao

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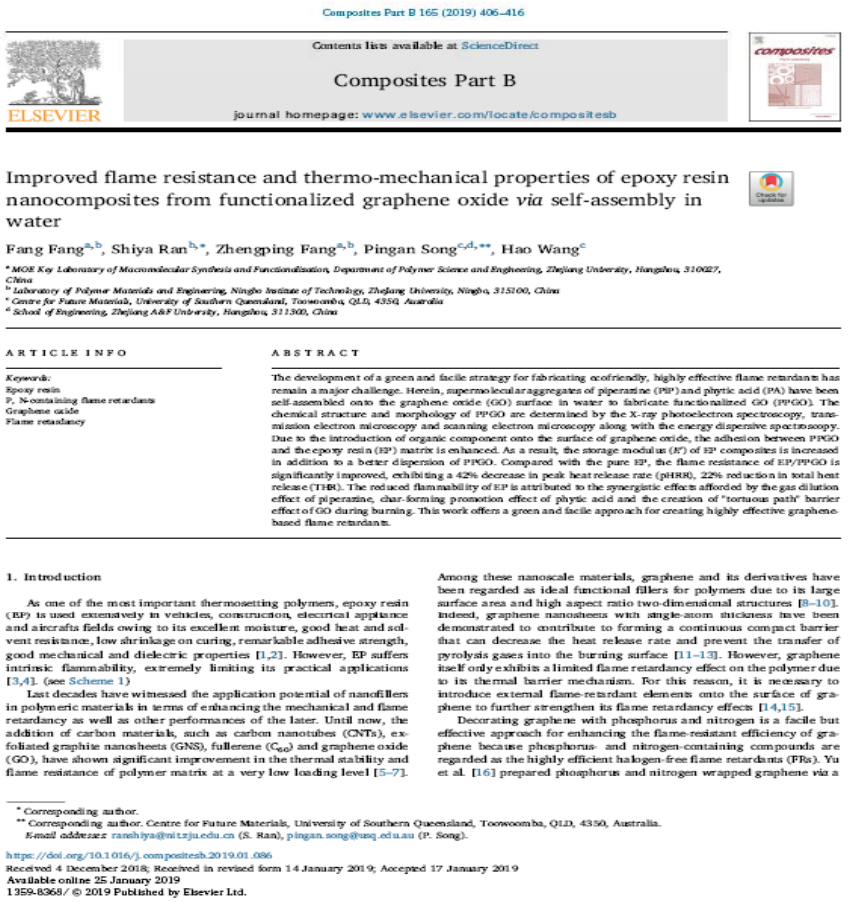

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Improved flame resistance and thermo-mechanical properties of epoxy resin nanocomposites from functionalized graphene oxide *via* self-assembly in water

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ABSTRACT

The development of a green and facile strategy for fabricating ecofriendly, highly effective flame retardants has remain a major challenge. Herein, supermolecular aggregates of piperazine (PIP) and phytic acid (PA) have been self-assembled onto the graphene oxide (GO) surface in water to fabricate functionalized GO (PPGO). The chemical structure and morphology of PPGO are determined by the X-ray photoelectron spectroscopy, transmission electron microscopy and scanning electron microscopy along with the energy dispersive spectroscopy. Due to the introduction of organic component onto the surface of graphene oxide, the adhesion between PPGO and the epoxy resin (EP) matrix is enhanced. As a result, the storage modulus (E') of EP composites is increased in addition to a better dispersion of PPGO. Compared with the pure EP, the flame resistance of EP/PPGO is significantly improved, exhibiting a 42% decrease in peak heat release rate (pHRR), 22% reduction in total heat release (THR). The reduced flammability of EP is attributed to the synergistic effects afforded by the gas dilution effect of piperazine, char-forming promotion effect of phytic acid and the creation of "tortuous path" barrier effect of GO during burning. This work offers a green and facile approach for creating highly effective graphene-based flame retardants.

1. Introduction

As one of the most important thermosetting polymers, epoxy resin (EP) is used extensively in vehicles, construction, electrical appliance and aircrafts fields owing to its excellent moisture, good heat and solvent resistance, low shrinkage on curing, remarkable adhesive strength, good mechanical and dielectric properties [1,2]. However, EP suffers intrinsic flammability, extremely limiting its practical applications [3,4]. (see Scheme 1)

Last decades have witnessed the application potential of nanofillers in polymeric materials in terms of enhancing the mechanical and flame retardancy as well as other performances of the later. Until now, the addition of carbon materials, such as carbon nanotubes (CNTs), exfoliated graphite nanosheets (GNS), fullerene (C_{60}) and graphene oxide (GO), have shown significant improvement in the thermal stability and flame resistance of polymer matrix at a very low loading level [5–7].

Among these nanoscale materials, graphene and its derivatives have been regarded as ideal functional fillers for polymers due to its large surface area and high aspect ratio two-dimensional structures [8–10]. Indeed, graphene nanosheets with single-atom thickness have been demonstrated to contribute to forming a continuous compact barrier that can decrease the heat release rate and prevent the transfer of pyrolysis gases into the burning surface [11–13]. However, graphene itself only exhibits a limited flame retardancy effect on the polymer due to its thermal barrier mechanism. For this reason, it is necessary to introduce external flame-retardant elements onto the surface of graphene to further strengthen its flame retardancy effects [14,15].

Decorating graphene with phosphorus and nitrogen is a facile but effective approach for enhancing the flame-resistant efficiency of graphene because phosphorus- and nitrogen-containing compounds are regarded as the highly efficient halogen-free flame retardants (FRs). Yu et al. [16] prepared phosphorus and nitrogen wrapped graphene *via* a

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  - 沈海峰, 邵胜栋, 王子路, 郭正虹*.聚乙烯亚胺修饰富勒烯的制备及其对聚丙烯热氧稳定性的影响. *复合材料学报*. 2020.4, 37(11): 2743-2748.
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- 张艳*，熊正权，李晓楠，方征平. 水相自组装生物基核壳膨胀型阻燃剂对聚乳酸的阻燃改性, *高分子材料科学与工程*, 2020.4接受

专利

- 申请发明专利 **2** 项
  - 闫红强，程捷，方征平. 一种提高改性苎麻织物阻燃性能的方法，申请号: CN202010447136.2，申请日: 2020.05.25
  - 赛霆，冉诗雅，郭正虹，方征平. 一种磷-氮基超分子稀土配合物及其制备方法和应用. 申请号: CN 202010978646.2，申请日：2020.09.17

授权发明专利 6 项

- 冉诗雅, 郭正虹, 方芳, 方征平. 聚乙烯/金属氢氧化物/科琴黑阻燃材料及其制备方法, ZL 201710799263.7, 申请日2017.09.07, 授权公告日2020.02.21
- 闫红强, 殷平, 程捷, 方征平. 生物质酚酞-糠胺型苯并噁嗪树脂及其制备方法, ZL 201810014012.8, 申请日2018.01.08, 授权公告日2020.04.21
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- 郭正虹，方征平，冉诗雅. 可抗高温氧化的聚丙烯材料及其制备方法，ZL 201810781159.X，申请日: 2018.7.17, 授权公告日2020.10.30
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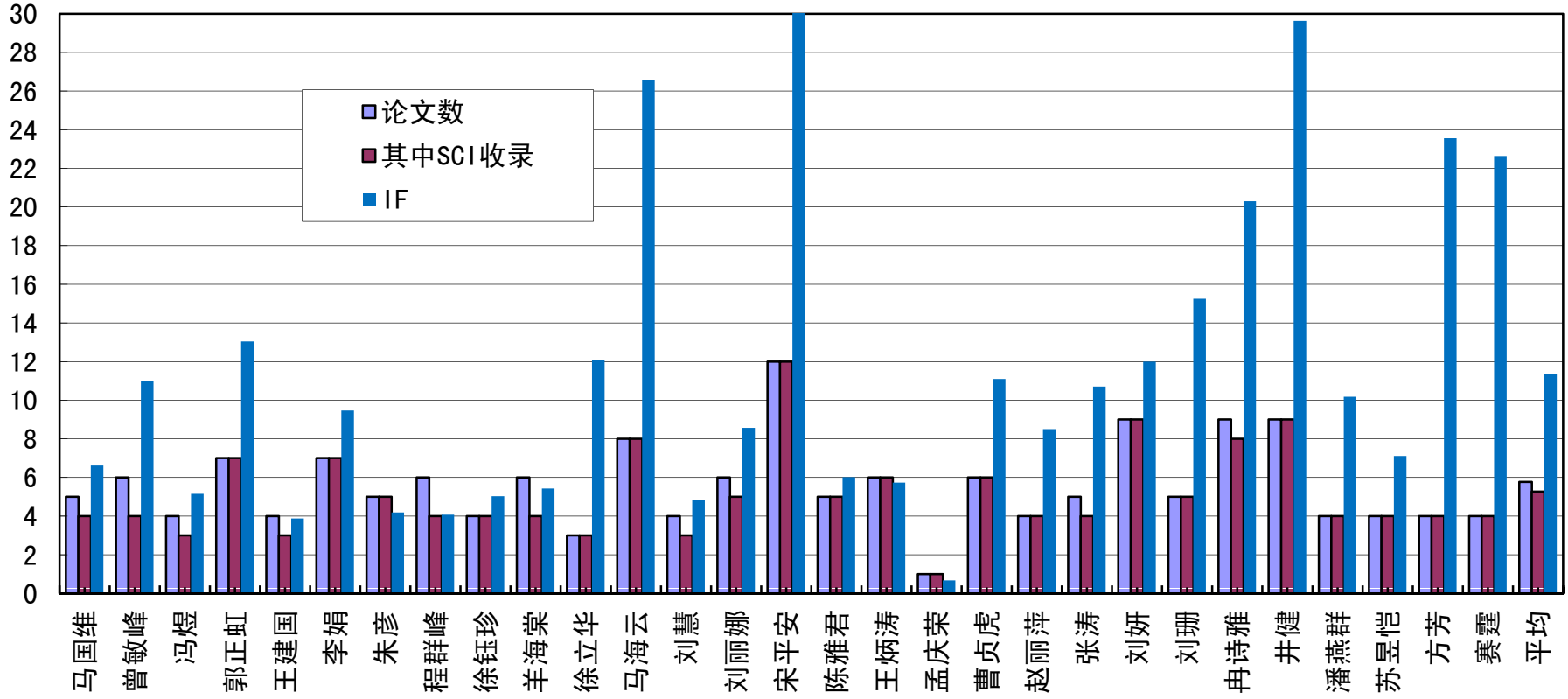
博士生成果统计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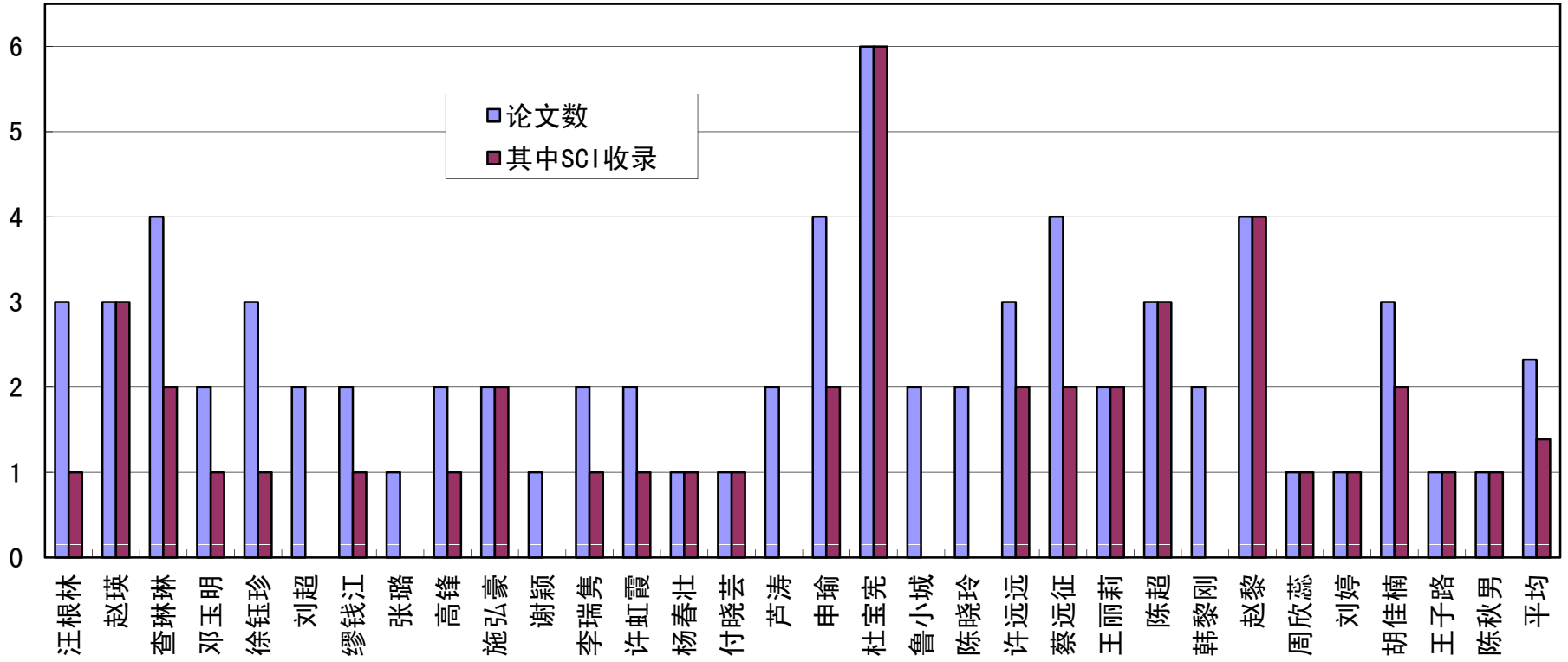
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