



EFFECT OF FULLERENES ON FLAME RETARDANCY OF POLYMERIC SUBSTRATES [REVIEW]

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Abstract: Flame retardancy is a modern challenge especially in living area applications as many flame retardants such as halogenated and brominated chemicals possess health risks. Studies show that fullerenes have potential for flame retardant applications. Flame retardancy property of fullerene included polymers is explained in this paper. Fire hazards have been risks for human beings through all history. In modern era, closed areas such as houses, offices and cars are full of organic and polymeric materials and possess serious fire risks. Organic polymers are widely used in many daily applications due to their mechanical properties and price availability. As organic polymers are flammable naturally, the flame retardancy of polymeric materials is becoming an important issue in living areas. Conventional flame retardant materials have found a large usage; however, they have some drawbacks as need of high level loading and environmental issues.

For flame retardancy applications, mainly seven elements are efficient in polymers: chlorine, bromine, aluminum, boron, phosphorus, nitrogen and antimony. Large amounts of conventional flame retardants are needed to ensure flame retardancy requirements. High loading levels of conventional flame retardants cause detrimental decreases in mechanical properties of the hosting polymer and cause transparency loss of the matrix material as well.

In conclusion, the effect of Fullerene (C60), as a nanocarbonaceous material, on flame retardancy properties of polymeric materials is explained. Fullerenes not only increase strength properties of polymeric substrates but also can enhance the flame retardancy of polymers. Fullerenes can alter the flammability of polymeric materials, which might find applications in many areas of our daily lives, and result in increased flame retardant properties of polymeric materials including textiles.

Key words: Fullerene (C60), flame retardancy, nanocarbonaceous materials, polymers, fabric substrates.

1. INTRODUCTION

Fullerenes are nanocarbonaceous materials consisting of at least 60 carbons and resembling soccer balls, illustrated in Figure 1. Fullerenes have been applied to polymeric substrates for a variety of properties including high energy storage, superconductivity, flame retardancy and reinforcing effect in polymers and polymeric fabrics as well [1-7].

Flame retardancy is a modern challenge especially in living area applications as many flame retardants such as halogenated and brominated chemicals possess health risks. Studies show that fullerenes have potential for flame retardant applications. Flame retardancy property of fullerene included polymers is explained in this paper.

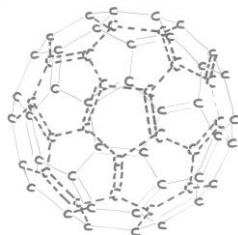


Fig. 1: An illustration of Buckminster fullerene (C₆₀) (illustrated by Keskin Reyhan).

2. FLAME RETARDANCY OF FULLERENE ADDED POLYMERS

Fire hazards have been risks for human beings through all history. In modern era, closed areas such as houses, offices and cars are full of organic and polymeric materials and possess serious fire risks; the flame retardancy of polymeric materials is becoming an important issue in living areas. Conventional flame retardant materials have found a large usage; however, they have some drawbacks as need of high level loading and environmental issues. For flame retardancy applications, mainly seven elements are efficient in polymers: chlorine, bromine, aluminum, boron, phosphorus, nitrogen and antimony [8]. Large amounts of conventional flame retardants are needed to ensure flame retardancy requirements [9]; hence, conventional flame retardants not only cause detrimental decreases in mechanical properties but also cause transparency loss in material [10].

To avoid mechanical property decreases, nano scale flame retardant materials are good alternatives to conventional flame retardants. Nano scale flame retardants offer good results in small loading levels [11]. As the flame retardant particle size decreases, particle distribution inside the polymer is increased and flame retardancy of the polymer matrix is improved [12].

Intumescent flame retardants have common usage due to their low toxicity and smoke release [12]. Intumescent flame retardants form a charred layer that cause a barrier for volatile chemicals so have a slowing effect in fires [13]. Kandola et al proved that intumescent can decrease the peak heat release values and enhance char formation [14]. Brominated flame retardants find large usage as they are not decreasing detrimentally mechanical properties of the hosting polymer; however, brominated flame retardants release large amounts of smoke and heat during combustion [15]. Nanoparticles such as nanoclays, carbon nanotubes and layered double hydroxides are also used as flame retardants in polymeric substrate, nanoparticulated flame retardants (nanoclays, carbon nanotubes) are environmentally friendly [9].

Char formation is a mechanism to promote flame retardancy [16]. As conventional flame retardants possess some health and environmental risks, efforts are increasing to find safer substitutes for conventional flame retardants [17]. Fullerene is another carbonaceous nanomaterial that has flame retardancy effect on polymeric materials [9].

Fire protection is a complex aspect. There are various parameters that are concerned in terms of flame retardancy such as cone calorimetry measurements (ignition time, heat release rate, peak heat release rate (PHRR) is about the danger of the fire, time to peak heat release rate, heat release rate (HRR) is about the speed of the fire, total heat release, average mass loss rate, average specific extinction area), nano scale flame retardants decrease peak heat release rate and suppress the danger level of the fire [9]. Carbon nanotubes and nanoclays decrease heat release rate [18, 19].

Fullerene, as a flame retardant, has potential to postpone beginning of combustion in fires [21]. Fullerenes are capable of capturing free radicals during combustion and improving the thermal stability of polymers [15]. Fullerene addition increases time for ignition and slows down combustion start; however, fullerene does not form a charred layer that forms a tortuous path for volatiles [18, 19]. Fullerenes do not form a network and do not block the movement of polymer chains since



they are spherical nanoparticles; indeed they offer more movement for polymer chains by acting like plasticizers [20]. Fullerenes have high affinity to free radicals [21]; during combustion fullerenes trap free radicals. Fullerenes and free radicals form a gelled-ball crosslink network. The flame retardation mechanism of fullerenes is effective in the combustion process by preventing heat flow and oxygen transfer from outer surface to inner parts owing to these gelled-ball crosslink networks [20]. Fullerenes have cooling ablative effect in between 600-1000°C temperature ranges besides their flame retardancy [22]. Fullerene has proven to increase not only time for ignition [23, 24] but also the LOI (limiting oxygen index) value [25] and to restrain combustion as well [26].

3. CONCLUSIONS

In conclusion, the effect of Fullerene (C₆₀), as a nanocarbonaceous material, on flame retardancy property of polymeric materials is explained. Fullerenes not only increase strength properties of polymeric substrates but also can enhance their flame retardancy. Fullerenes can alter the flammability of polymeric materials, which might find applications in many areas of our daily lives, and result in increased flame retardant properties of polymeric materials including textiles.

As the result of this paper, fullerene (C₆₀) appears to be a promising reinforcing nanomaterial for flame retardancy of polymeric materials. The addition of fullerene (C₆₀) to polymeric materials can bring enhanced unflammability to many products used in the automobile industry, upholstery industry, construction industry and in polymeric composites.

ACKNOWLEDGEMENT

This research was supported by Pamukkale University Scientific Research Projects Institute (PAUBAP) under the project number 2011BSP019.

4. REFERENCES

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