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Fluorescent PLA filaments: 3D printing with fluorescent inks

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INTRODUCTION & AIM

In line with the rapid adoption of 3D printing in both industrial and academic fields, the development of functional materials compatible with 3D printing applications represents a promising direction for the continued advancement and adoption of additive manufacturing technologies.[1]
In this article, we will explore the application of fluorescent latexes in preparation of fluorescent filaments to create smart objects via 3D printing technology.

METHOD

Materials

Sodium dodecyl sulfate, sodium bicarbonate, triton X-100, methyl methacrylate, Hydroxyethyl methacrylate, ethylene glycol dimethacrylate, acrylamide, and potassium persulfate were purchased from merck. Industerial grade of 2,5-bis(5-tert butyl-2-benzoxazolyl) thiophene fluorescent compound was used in this project.

Synthesis of polymer particles

0.07 g of sodium dodecyl sulfate, 0.01 g of sodium bicarbonate, and 0.01 g of triton X-100 was added to 6 ml of water and mixed with a magnetic stirrer for 15 min at 200 rpm under argon atmosphere. Then, 0.8 g of methyl methacrylate, 0.1 g of 2 -Hydroxyethyl methacrylate and 0.02 g of ethylene glycol dimethacrylate were mixed and prepared in a seringe. Then, in another seringe, 0.1 g of acrylamide dissolved in 2 ml of water was prepared. Both solutions were simultaneously added to the first flask in 10 min and stirred for 15 min. Then 0.01 g of potassium persulfate dissolved in 1 ml of water, was added to the flask slowley. The reaction was stirred for 40 min at 80 ºC under argon atmosphere. The resultant emulsion did not need furthur purifications.[2]

Fabrication of fluorescent filaments

2,5-bis(5-tert butyl-2-benzoxazolyl) thiophene fluorescent compound (equivalent to 5% of the total weight of solid polymer particles in the latex) was added to the Latex (2 ml). Then the mixture was stirred for 72 hours at room temperature. The process of creating fluorescent filaments consisted of mixing PLA and fluorescent-latex (BBT-latex) without any dilution and transfering them into an extroder instument to prepare fluorescent filaments.

RESULTS & DISCUSSION

FTIR spectroscopy was used to investigate functional groups of polymer particles in latex. According to Fig. 1 the absorption band at 1740 cm^{-1} is attributed to the carbonyl stretching of the ester groups in MMA and HEMA which overlap each other, and the absorption band at 1660 cm^{-1} is attributed to the carbonyl stretching of the amide groups in AAm.

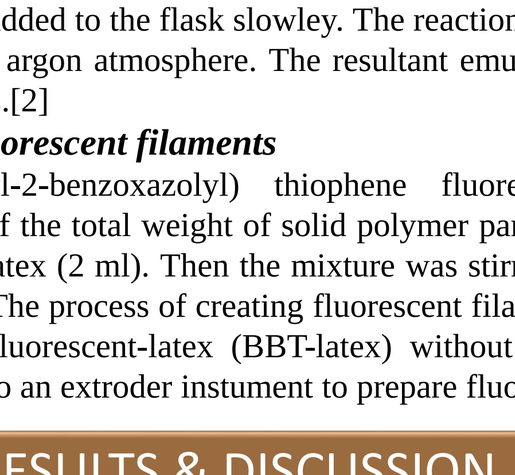

Fig 1. FTIR spectra of functionalized latex

The size of the polymer particles were investigated via DLS experiment. As shown in Fig. 2 the particle size of polymer particles is 156.9 nm with poly disspersity index (PDI) of 0.27.

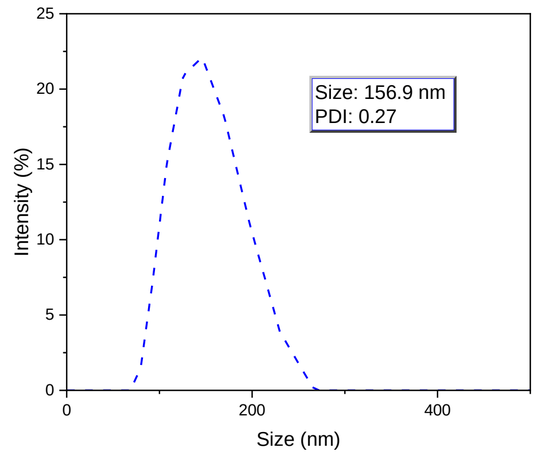

Fig 2. DLS curves for functionalized latex

The optical characteristics of the photochromic latex

The white BBT-latex exhibited strong green fluorescence under dark conditions (Fig 3), promoting our interest in exploring its use as a fluorescent ink for PLA-based filament production. A pictuce of PLA based filament and a PLA based filament containing BBT-latex is depicted in Fig 4.

Fig 3. BBT-latex under dark condition

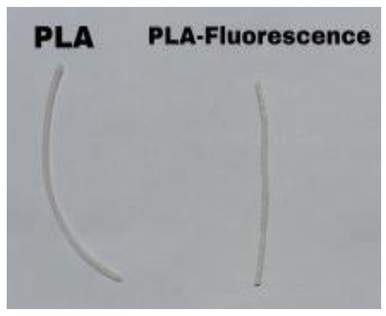

Fig 4. A picture of PLA-based filament and a fluorescent PLA-based filament

3D printing using fluorescent filament

A 3D printer was employed to fabricate a pyrimide shape using the PLA filament containing BBT-latex, resulting in a structure that displays a white color under daylight conditions and shows intense green fluorescence in the absence of light (Fig 5).

Fig 5. 3D printed pyrimide using PLA filament containing BBT-latex under daylight (top) and dark condition (down)

Our observations confirmed that BBT-latex caused fluorescence emision in the filament and the 3D printed final object alongside with increasing stength of the filament due to presence of polymer particles.

CONCLUSION

In this project, we prepared fluorescent latexes and subsequently, we explored the application of them in fabrication of fluorescent filaments to create fluorescence light emiting objects via 3D printing technology.

FUTURE WORK / REFERENCES

[1] Brubaker, C., Frecker, T., Mcbride, J., Reid, K., Jennings, G., Rosenthal, S., & Adams, D. (2018). Incorporation of fluorescent quantum dots for 3D printing and additive manufacturing applications. *Journal of Materials Chemistry C*, 6, 7584-7593.
[2] Norouzi M,Ahmadi E, Mohamadnia Z. Stimuli-responsive fluorescent polymer nanoparticles: Versatile applications in rapid colorimetric and fluorometric detection of cyanide in blood plasma, pH sensing, paper-based sensors, and intelligent artworks. Journal of Photochemistry and Photobiology A: Chemistry. 452, (2024), 115552.