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New Method for Assembly of Perylene Bisimide Based 1D-Nanostructure

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Abstract

Perylene bisimide (PBI) is an archetype motif for creating functional supramolecular materials. PBI based 1-D structures looks promising for being used in creation of optical neural network based photonic chips. The photonic chip created using 1-D photonic wires are considered to provide much better platform to run massive AI (artificial intelligence) algorithm with far improved energy and speed efficiency. Here, we describe a new crystallization technique to assemble dicyclohexyperylene bisimide in 1-D structure, and their characterization using scanning electron microscopy.

Introduction

Perylene bisimide (PBI) are privileged structure used to create mainly supramolecular one dimensional architecture. [1, 2] Facile π- π stacking, H-bonding[3] and ionic interactions[4] shown by various PBI molecules are utilized to create various 1-D structures such as nanobelt, nanowires, nanorod and helices.[1]

Nanowire based optical wave guide have emerged as important components for making a photonic chip.[5, 6] These photonic wires could be used to create optical neural network needed for deep learning circuits of artificial intelligence (AI) based devices.[7, 8] Optical neural network based photonic chip could enhance energy efficiency and speed of AI based devises drastically.

Inspired by probable use of photonic nanowires in creating optical neural network based chip, we studied assembly of previously reported cyclohexyl perylene bisimide based 1-D nanostructure by a serendipitously discovered novel procedure. We also examine these wires for their suitability to be used as photonic wire in optical chip. The properties that are needed for 1-D structure to be suitable for photonic chip are: (1) It should avoid re-absorption of propagating light for which a large stokes shift is needed in these wires. (2) It should reduce scattering loss during light propagation for this the wires must have uniform geometry and smooth surface. (3) 1-D structure should be made from high purity crystals which should also be well oriented for high PL efficiency.[9]

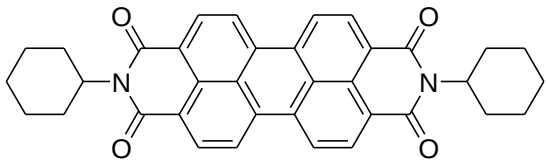
Results and Discussion

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Cyclohexyl perylene bisimide (Fig. 1) was synthesized by literature reported method and characterized by TLC analysis and UV-VIS spectra.[10] PBI, **1** was fabricated to 1-D nanostructure using bulk solution phase transfer method by Zang et al. However, these in our case these nanostructures are generated during purification of **1** by crystallization method.



1

Figure 1. Structure of perylene bisimide **1**.

A clear dichloromethane solution of **1** was formed in a beaker in which methanol was added drop wise until slight turbidity developed (See experimental). The solution was left undisturbed overnight. Wires were created as floating bulk (like a plug of cotton) in mother liquor (Figure 2).

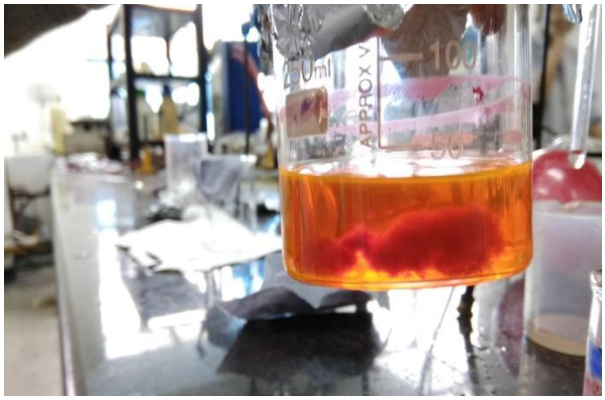


Figure 2. Appearance of PBI 1 wire in solution during crystallization.

These wires were taken on cover slide for their SEM analysis. As shown in SEM image (Figure 3), wires with different width was formed and few were (red arrow) found to possess same dimension as the wire used by Zang et al. for measuring their wave guide properties.[10]

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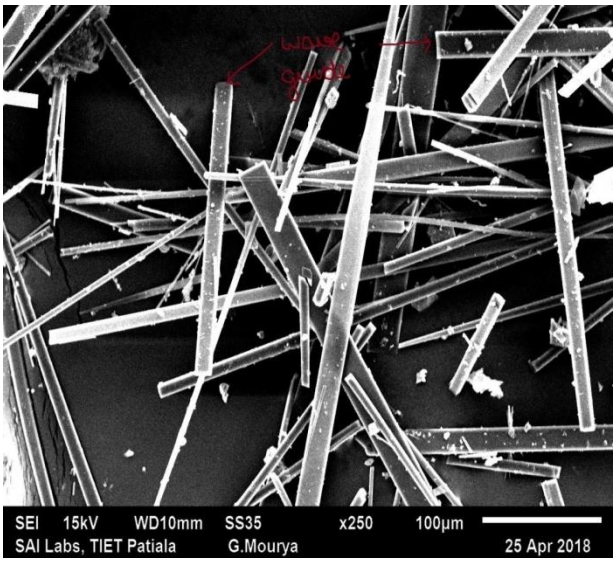


Figure 3. SEM images of 1-D nanowires formed by different procedure.

It was also observed looks that these organic wires have good flexibility as shown in SEM image of Figure 4 (red line). Due this flexibility these wire could easily be manipulated using microprocessor for fabrication of photonic chip.

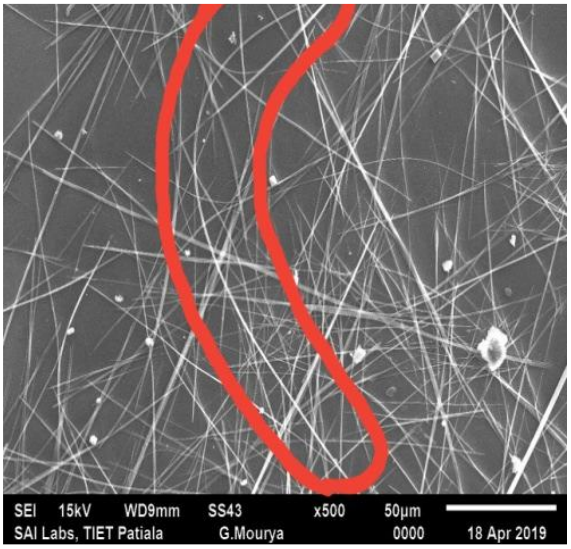


Figure 4. SEM image showing the flexibility of 1-D wire of PBI-1.

Conclusion:

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We synthesized perylene based 1-D crystalline nano-wave guide for studying their suitability as component of photonic chip. In fabrication of the nano waveguide we used novel crystallization method. These photonic wires have similar crystalline shape and dimensions as reported in literature.[10] Surprisingly, these wires were also found to possess good flexibility. 1-D structure based on cyclohexyl perylene bisimide looks promising for being used for fabrication of photonic chip. Their photon conducting ability would be published in next report.

Experimental:

*Synthesis of perylene bisimide **1***: Take a RBF of 100 ml. Take 0.5g of perylene. Add 17ml of DMF. Now add 0.379g(0.43ml) of cylco hexylamine. Reflux it at 130-140 C for 5-6 hours. When the reaction is complete add 100 ml of 1M HCl and 33ml ethanol. Stir for 2-3 hours. Wash it with water several times. Filter it and weigh it after drying. Yield: 0.56g

*Fabrication of of perylene bisimide **1***: Take 50mg of crude product. Dissolve in 10ml DCM. Take out 2ml and add DCM until a clear solution is obtained (90ml DCM). Filter the solution. Add methanol(20ml) to it dropwise till the solution becomes turbid. Keep it undisturbed for overnight. Cover it with foil paper and make holes in it. Wires were obtained. Filter it and weigh it. Wt. of precipitate-0.011g

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