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Synthesis of Polydopamine Nanoparticles for Drug Delivery Applications

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For decades, pharmaceutical sciences have been using nanoparticles for drug delivery in order to reduce toxicity and side effects of drugs. Therefore, biodegradable and biocompatible nanocarrier is essential to deliver the drug within the therapeutic window [1]. A wide range of nanoparticles have been developed so far as carriers of drugs and other biomolecules such as liposomes, dendrimers, polymeric nanoparticles, mesoporous silica etc.[2] However, such nanocarriers required complicated procedures and instrumentation for their synthesis and fabrication. Herein, we have reported the synthesis of polydopamine nanoparticles (PDA NPs) by using a very simple procedure without involving harsh reaction conditions and complicated instrumentation.

PDA is a dark brown black insoluble biopolymer, obtained by the auto-oxidation of its monomer dopamine (DA). DA is a catechol neurotransmitter that occurs naturally in human and is responsible for various brain functions [3]. PDA NPs were synthesized by the spontaneous oxidation of DA under alkaline conditions at room temperature. Briefly, a small quantity of DA was dissolved in a mixed solution of water, ethanol and ammonia. This mixture was kept under stirring for 24 h at room temperature in the presence of atmospheric oxygen. Product formation is accompanied by color change of the solution from colorless to pale yellow and then brownish black with the passage of time. Afterwards, particles were sedimented by centrifugation at 15,000 rpm for 15 mins, followed by washing with water and drying in oven at 80 $^{\circ}$C for 4 h.

The resulting particles had a negative zeta potential of -29 mV, as measured by zeta sizer. Scanning electron microscopy (SEM) image confirmed uniform spherical morphology of the particles with an average size of about 180 nm (Figure 1a). UV-visible spectrum showed broad absorption of PDA in UV-visible range (Figure 1 b). Additionally, Fourier transform infrared spectroscopy (FTIR) of DA powder and PDA NPs were measured to determine characteristic functional groups before and after polymerization of DA, (Figure 2 a). The FTIR spectrum of DA showed characteristic peaks at 3037 and 2956 cm^{-1}, which is attributed to the aromatic O-H stretching vibrations. The narrow peaks at 1319, 1184, and 1174 cm^{-1} is attributed to the C-O-H bending vibration, C-O symmetry vibration, and C-C stretching vibration modes, respectively. The sharp peaks at 1470 and 1479 cm^{-1} is corresponding to the stretching vibrations of benzene ring.[4, 5] In contrast to the FTIR of PDA NPs, the broad band from 3000-3600 cm^{-1} is attributed to the stretching modes of N-H and O-H bonds. Moreover, the peak at 1558 and 1506 cm^{-1} is due to the stretching of aromatic C=C bonds of indole, and the peak at 1166 cm^{-1} was corresponding to C-N bending in indolequinone.[6] From the above results, it has been found that the presence of indole and indolequinone structures in FTIR spectrum of PDA proved the successful polymerization of DA to PDA.

Therefore, the above results confirmed the successful synthesis of PDA NPs. These NPs would be further investigated for the drug loading and release applications in future work.

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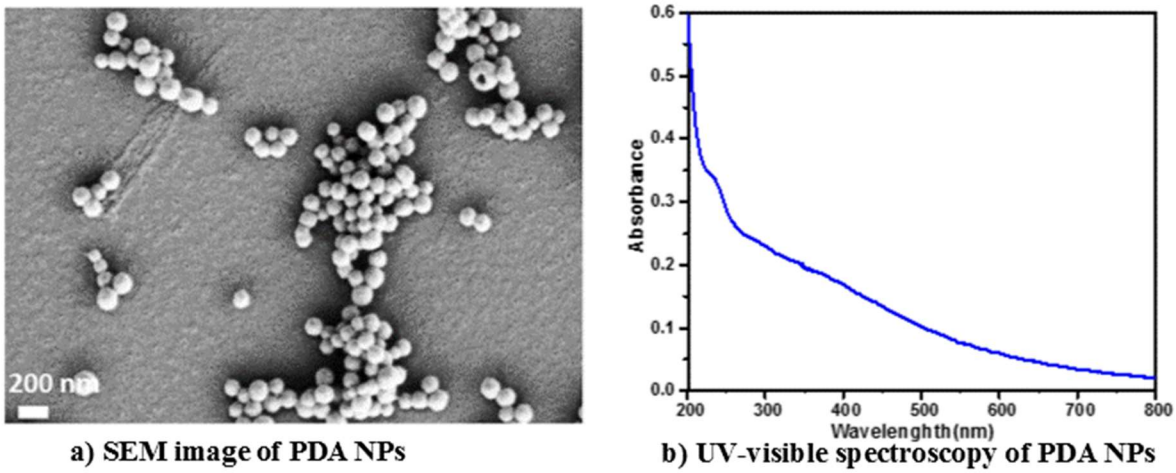

Figure 1. (a) SEM image and (b) UV-visible spectroscopy of PDA NPs.

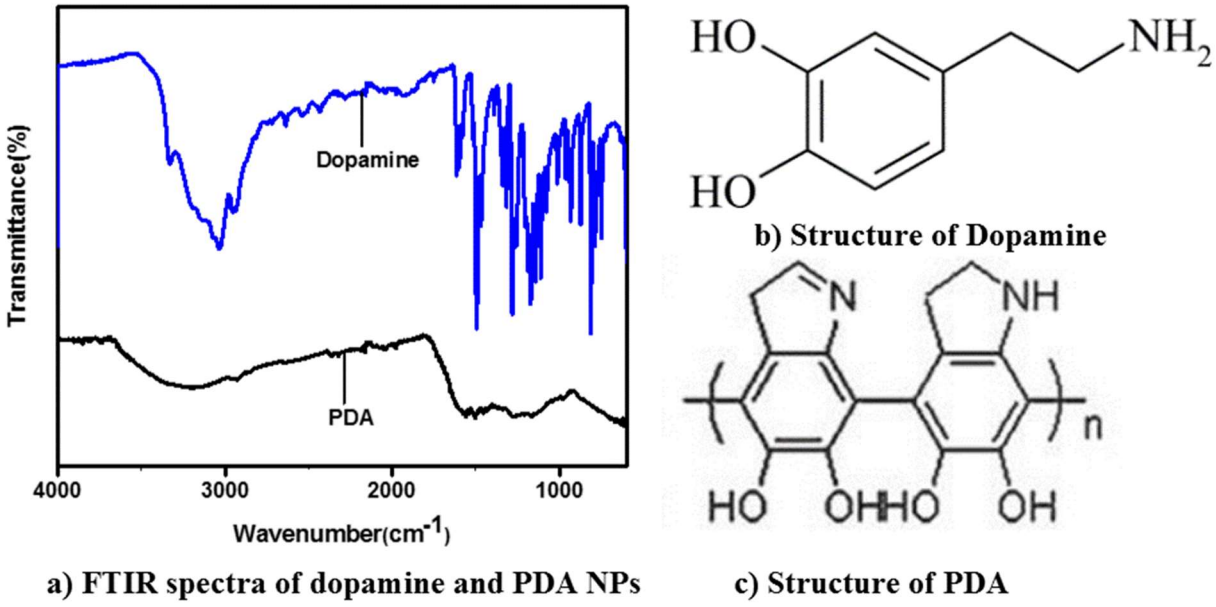

Figure 2. (a) FTIR spectra of dopamine and PDA NPs; Chemical structures of (b) dopamine and (c) PDA respectively.

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