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Antibacterial Potential of Polypyrrole Fabricated By Chemical Oxidation Protocol

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Abstract:
Polypyrrole (PPy), a most promising conducting polymer of present vintage was fabricated by using chemical oxidative polymerization at 30°C. The synthesized polymer was characterized by FT-IR and NMR technique. The antibacterial potential of polymer assessed against the Gram-negative *E. coli* (ATCC 8739) and the Gram-positive *S. aureus* strains (ATCC 6538) pathogenic bacteria by agar well diffusion method. Both microorganisms were inhibited in presence of polypyrrole like penicillin specifies chemically fabricated polypyrrole (PPy) exhibits good antibacterial potential.
Keywords: *Polypyrrole (PPy); Chemical oxidative polymerization; Antibacterial; etc.*

1. Introduction

Conducting polymers (CPs) are most broaden area of material science that fascinated whole community of researcher, scientist, and electronic industries. The attraction of CPs is due their wide range of applications [1-6] like biosensors, gas sensors, wire, micro-actuators, anti-electrostatic coatings, solid electrolytic capacitor, electro chromic windows and displays, polymeric batteries, electronic devices and functional membranes [7-8], etc. Among all conducting polymer, polypyrrole (PPy) attracted much attention in last two decades because of its enormous significant properties like facile synthesis [9-11], excellent environmentally stability and highly appreciable technological applicable possibility. Continuous and rigorous efforts are also devoted to investigate antimicrobial potential [12-13] of polypyrrole for its advancement as new biocides.

It is need of hour to formulate and develop alternative biomaterial for conventional material as they have certain limitations. Polymers like polypyrrole have lots of such physical and a mechanical property [14] suited for ideal biomaterial to assure customized and optimized long term clinical outcome. At the same time these polymeric biomaterial can be modified by numerous techniques [15] up to nonmaterial stage for better effectiveness. In the same view herein, we attempt to enhance the scope of chemically fabricated polypyrrole for its antibacterial activity.

2. Materials and Method

2.1: Chemicals: Pyrrole (SRL Pvt. Ltd., India) monomer was used as received without further purification. Ethanol, DMSO (Loba Chemicals, India), was used as solvent. Anhydrous $FeCl_3$, (S.D. Fine Chemicals, India) oxidant was used as received. Double distilled water was used for the preparation of all reagents and chemicals.

2.2: Sample Preparation: In round bottom flask; 100 ml 0.02 M pyrrole monomer was prepared in water by continuously stirring on magnetic stirrer for 1 hour at 30°C. To this reaction mixture separately agitated 100 ml 0.06 M $FeCl_3$ as oxidant [9, 11, 16] was added dropwise in 1:2 mole ratio. As soon as the pyrrole mixed with the oxidant ($FeCl_3$), it turned to characteristic black colour indicating polymerization reaction started. After 3 hours black Polypyrrole powder was obtained. The product was washed with distilled water several times to remove any impurities present and followed by ethanol and dried at 60-70°C in hot vacuum oven (Accu-lab) and stored in dry and dark place.

2.3: Antimicrobial component: Mueller-Hinton agar, Broth culture of both test microorganism, Gram-negative *E. coli* (ATCC 8739) and the Gram-positive *S. aureus* strains (ATCC 6538) were used for further study. Sterile water was used for serial dilutions. Penicillin was used as reference antibiotics. Dimethyl sulfoxide (S.D. Fine Chemicals, India) was solvent for all aforesaid concentration. Petri dishes (9 cm in diameter) were incubated at 37°C for 24 h.

2.4: Minimum Inhibitory concentration (MIC) measurement: The micro dilution susceptibility test in Mueller-Hinton agar was used for the determination of antibacterial activity. Stock solution of polypyrrole was prepared in dimethyl sulfoxide. Each stock solution was diluted broth method to prepare two fold dilutions of broth containing about 106 CFU/ml of test bacteria was added to each well of 96-well micro titer plate. The sealed micro plates were incubated at 37°C for 24 h in humid chamber. At the end of incubated period polypyrrole showed antibacterial activity against both test microorganism, Gram-negative

E. coli and the Gram-positive *S. aureus* strains. The MIC value of polypyrrole was about 0.05 g/ml against both test bacterial culture.

3. Result and Discussion

3.1: Characterization

A FT-IR (Fig.-1) and NMR spectrum (Fig.-2) is used for confirmation of formation of polypyrrole. The characteristic peaks at 1560.7 cm^{-1} and 1303.1 cm^{-1} correspond to the C=C stretching, whereas peaks at 1685.7 cm^{-1} and 1315.4 cm^{-1} represent to respectively, C=N and C–N bonds [16]. The occurrence of small peaks at 3125.3 cm^{-1} is assigned to presence of N–H stretching vibrations. The peaks observed in the present work match well with the ones available in the literature [17-19] confirming the formation of Polypyrrole.

NMR values for polypyrrole are δ at □0.8743, 1.1424, 0.8743, 0.8743 gives N-H peaks while δ at1.25, 1.2511, 1.2502, 1.2554 gives pyrrole peak. The ^1H NMR spectra show linkage between two monomers of pyrrole at α - α' position which correlates with available [20-21] resource of literature.

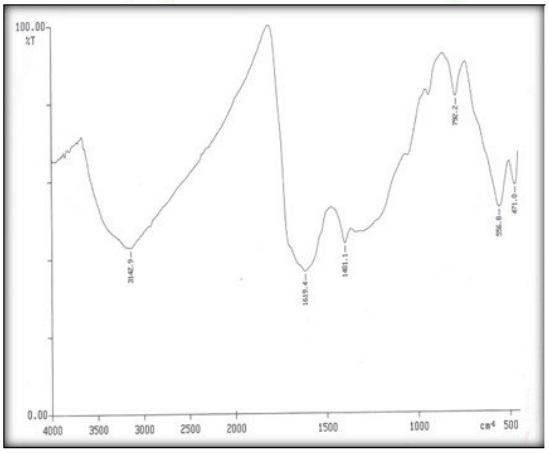

Fig.-1: FT-IR spectra of Polypyrrole (PPy)

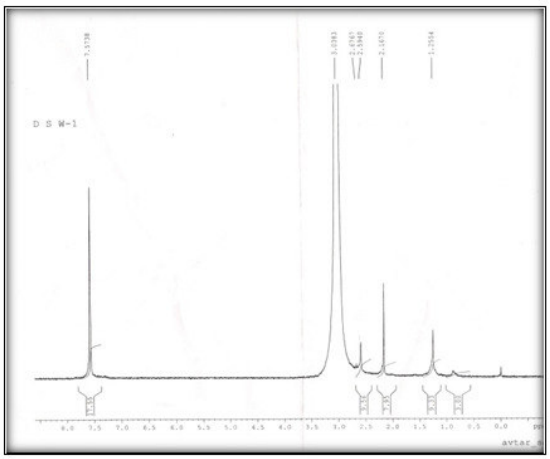

Fig.-2: NMR spectra of Polypyrrole (PPy)

3.2: Anti-bacterial Potential

Prior to antimicrobial testing, the polypyrrole was disinfected by an exposure to an UV-radiation source (258 nm) emitted from a low-pressure Hg lamp (UV-C Long Life 30 W/G30TB, Phillips, Netherlands). Polypyrrole is stable under such treatment [22]. As test bacterial culture, the Gram-negative *E. coli* (ATCC 8739) and the Gram-positive *S. aureus* strains (ATCC 6538) were used. Mullar Hinton agar (Hi-Media Laboratories, India) was used in the test.

Observation of polypyrrole against *S. aureus* (Table-1) in different concentration like original solution, 100mg/ml solution and 50 mg/ml showed zone of inhibition in 20mm diameter so, *S. aureus* was sensitive to polypyrrole that inhibit the growth of *S. aureus*. But in last concentration of 25 mg/ml it showed the zone of inhibition less than 10mm indicates that it was resistive. All these result are compared with penicillin as reference antibiotics that showed zone of inhibition of 20mm confirmed sensitivity to penicillin.

In case of *E. coli* (Table-2) in different concentration like original solution, 100 mg/ml solution and 50 mg/ml showed zone of inhibition in 13 mm diameter so, *E. coli* is sensitive to polypyrrole that inhibit its growth. But in last concentration of 25 mg/ml it showed the zone of inhibition less than 10mm indicates it was resistive.

Table 1: Observation table for Polypyrrole against *S. aureus*

Concentration (mg/ml)	Zone of inhibition	Diameter (mm)	Action against *S. aureus*
Original Sol.	+	20	sensitive
100	+	20	sensitive
50	+	20	sensitive
25	+	<10	resistance
Penicillin	+	20	sensitive

Table 2: Observation table for Polypyrrole against *E. coli*

Concentration (mg/ml)	Zone of inhibition	Diameter (mm)	Action against *E. coli*
Original Sol.	+	13	sensitive
100	+	13	sensitive
50	+	13	sensitive
25	+	<10	resistance
Penicillin	+	13	Sensitive

Conclusion

Polypyrrole prepared by conventional chemical oxidation protocol in powder form. FTIR and NMR spectral characterization confirms the formation of Polypyrrole in low cost and it evaluated for antibacterial activity. It is observed that the concentration of Polypyrrole is independent on the antimicrobial activity. It exhibits good antibacterial potency against *S. aureus* (ATCC 6538) and *E. coli* (ATCC 8739) bacteria by inhibiting the growth of both test culture in minimum inhibitory concentration with MIC value about 50 mg/ml. The result was almost equivalent to standard drug Penicillin. Result confirms that Polypyrrole is biologically active that realistically will acquire definite place in revolutionary safe and sound green biomaterial in future.

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