Pulsed Electrospinning Of Biopolymers

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Influence of charge on biopolymer configuration has been extensively studied (1). Such interactions play a role in polymer folding, cell regulation, and polymer stability. High voltage electrospinning of polymer fibers has been reported by other investigators (2). We devised an electric pulse method to produce fibers of DNA or prothrombin at very low voltages eg. between +0.5 and +1.0 volt. This is in the usual range of electrochemical methods.

An Ecochemie electro-analytic system was used to produce a series of pulsed electronic signals to the purged polymer samples to adapt an impedance spectroscopy protocol to the electro-deposition. A descending log series of pulses starting at a kilohertz was utilized. However the voltages (+0.5 to +1.0) and pH (5.0 to 5.5) were selected for corrosion and electro-deposition of cations derived from the Hg drop (Hg^{+1}), into the polymer solution. It was necessary to pre-mix (5 mg/mL solutions) both the DNA (Sigma: calf thymus or salmon sperm) and the prothrombin with hyaluronic acid (Sigma) to reliably produce intact fibers, as reported in a non-pulsed method (3). The fiber formation was found to be electrolyte dependent. We used 9.0 mL of an equimolar mixture of KCl and $NaOOCCH_3$ buffer (0.05 M) at pH 5, after many trials, with 1.0 mL of the pre-mixed sample.

In each run, seven or eight fibers were spun and collected on small cover slips placed in the bottom of the sample cup in a slanted position. These were later removed and viewed under 300X phase microscopy. Multiple fibers were produced to simplify locating the small fibers microscopically.

The microscopic appearance of DNA fibers consists of sparse parallel filaments with refractile granules (fig. I). At higher magnification, the DNA filaments are seen to form loops and interconnections (fig. II).

The microscopic pattern of prothrombin fibers is an abundant array of parallel fibers (fig. III).

In both cases the integrity of the fiber structure is dependent on an association with the biological matrix polymer, hyaluronic acid. This common structure is a subject of further study, but is believed to be related to hydration and charge exchange between the polymers. Such charge exchange is a requirement for mutual inductance in twin- wire transmission cables. The implication is that hyaluronic acid has unique dielectric properties for its role in biological matrix.

The additional requirement for potassium in the formation of these fibers, and in its essential role in biological systems, is believed to proceed from highly specific hydration site requirements in biopolymers.

References

1. Bloomfield,V.A., Crothers,D.M., Tinoco Jr.,I., Nucleic Acids, University Science Books, CA, 2000.
2. Gibson,P., Schreuder-Gibson,H., Pentheny, C.J., Coated Fabrics, 1998,28, 63-72.
3. Garnett,M., Remo,J.L., 200th Meeting Electrochem. Soc. Sept.2001, 1132.

Figures

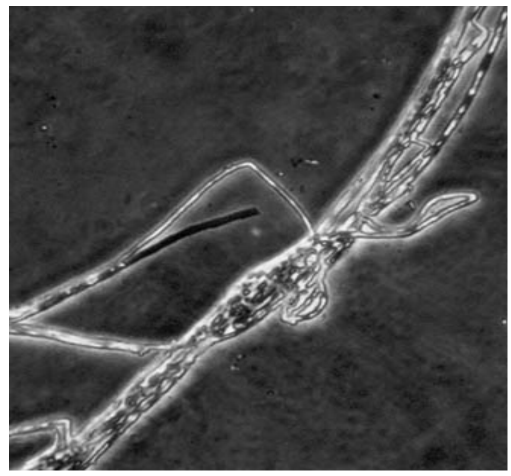

Fig. I

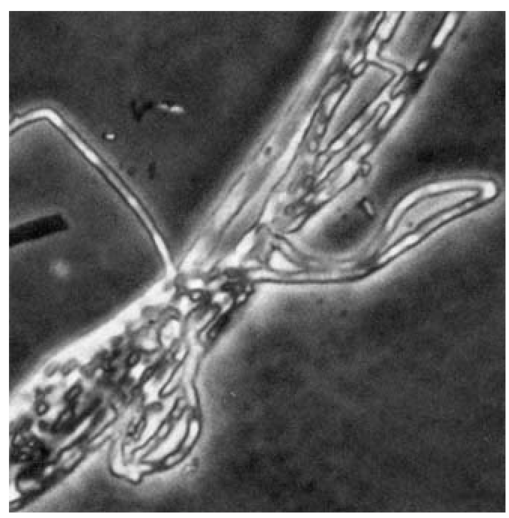

Fig. II

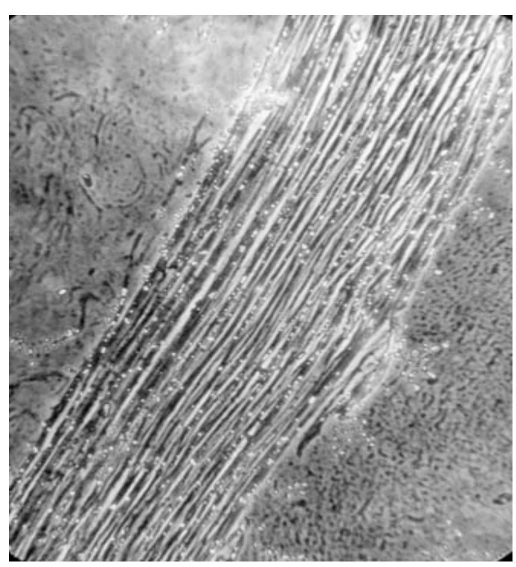

Fig. III