

Blood-Catalyzed Polymerization Generates Conductive Polymer in Live Zebrafish

Demonstrated in zebrafish, blood-catalyzed formation of conductive polymer (n-PBDF) opens bioelectronics and in-vivo sensing routes.

Researchers at Purdue have synthesized a blood catalyzed, electrically conductive n-doped polymer (dubbed n-PBDF) through in vivo polymerization in a zebra fish embryo. Conductive polymers (CP) have gained attention for their possible use in biomedical applications such as bioimaging, biosensors, neural interfaces, and drug delivery for charged drug molecules, with zebrafish embryos emerging as a potential platform for biomedical applications due to their high throughput and cost-effective breeding and screening, ease of genetic manipulation, and relevance for human applications. However, current CP formulations for biomedical applications require injection of pre-polymerized CPs into living tissue, increasing complexity and causing possible plugging of vasculature or aggregation around neurons for neural stimulation applications. Other methods involve genetic modification of living systems to produce enzymes for in vivo polymerization of the CP monomers, which is not ideal for human applications.

The researchers discovered that whole human blood effectively acted as a catalyst to produce n-PBDF CPs. Additionally, the researchers verified the ability to produce n-PBDF CPs in vivo, in a zebra fish embryo, with low toxicity observed.

Technology Validation:

The formation of n-PBDF conductive polymer was verified in vitro by conducting a kinetics study in which 25 mM BDF (the monomer) is dissolved in RPMI-1640 media with 10% FBS and 0.1 mol% Hb and measuring the spectrogram of the solution for 360 minutes in UV-Vis-NIR. The overall absorbance of the solution increased with time, especially in the Vis-NIR region, indicating polymerization of BDF to n-PBDF. The conductivity of the polymer was improved when using RPMI media with 10% FBS as the solvent, as compared to PBS with Hb, giving a maximum conductivity of 1.6 S/cm at

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0.5 mol% Hb. By observing the reaction kinetics under UV-Vis-NIR spectroscopy, the researchers discovered that whole human blood acted as a more efficient catalyst for polymerization than isolated red blood cells, and that the minimum concentration of the monomer necessary for polymerization using this method was 5 mM BDF.

The ability to polymerize BDF monomers in vivo was tested by injecting zebrafish embryos with 1 mM – 15 mM BDF monomer with 1% w/v TPGS in PBS and incubating at 34 °C for 24 hours. Polymerization was verified in vivo by measuring the absorbance of the control and experimental zebrafish embryos, with strong peaks observed at 960 nm in the experimental group, indicating successful polymerization of the monomer. All embryos injected with 5 mM BDF and above were observed to darken the yolk with the n-PBDF. Additionally, at least 80% of the BDF-treated embryos survived the full 24 hours of incubation and showed similar movement to the control embryos, indicating low toxicity of the polymer. When tested against A549 lung-cancer cells, the researchers found the n-PBDF polymer to be non-toxic, with viability remaining near 100% regardless of the polymer concentration. When incubated with the monomer however, the cancer cell viability dropped to 75% and 10% for monomer concentrations of 5 µg/mL and 0.167 mg/mL, respectively, in a 72-hour assay.

Advantages:

- Blood catalyzed; minimal reactants introduced to living system
- Low toxicity in zebra fish embryo and A549 lung-cancer cell model
- Relevant for human applications

Applications:

- Bioimaging
- Biosensors
- Bioelectronics
- Neural interfaces
- Drug delivery

TRL: 4

Intellectual Property:

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