Rapid and continuous monitoring of serotonin in cellular environments by phosphorescent nanofiber scaffolds

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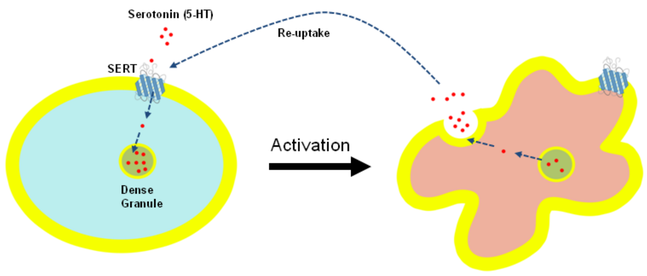
ABSTRACT

Serotonin is implicated in the control and function of a host of bodily functions, acting as a neurotransmitter, hormone, and cardiovascular growth factor. Detecting the release of serotonin in whole blood can be an important diagnostic tool in assessing conditions such as depression, schizophrenia, carcinoid syndrome, and cardiovascular disease.

Current techniques for the detection of serotonin levels in whole blood can be time consuming and destructive. In this presentation, we present a nondestructive and fast method for the detection of serotonin in whole blood using phosphorescent nanofibers. These nanofibers have a hydrophobic core, which contains an oxygen-sensitive dye and a reference dye, as well as a collagen exterior conjugated to monoamine oxidase (MAO). MAO converts secreted serotonin to a metabolite by consuming environmental oxygen. This conversion leads to localized deoxygenated areas which cause the interior oxygen sensitive dye to phosphoresce, indicating the presence of serotonin. This response has been tuned to an optimal sensitivity, response time, specificity over competing analytes, and sensor lifetime, thus yielding a reversible sensor that quantitatively detects serotonin *in vitro* and operates in real time. A quantitative increase in phosphorescence in response to serotonin released by platelet progenitor cells and late stage platelets was determined. In response to buffer treatment phosphorescence levels decreased, demonstrating the reversibility of these nanofibers. These nanofibers have an application as a novel tool for the continuous monitoring of analytes in whole blood.

CLINICAL NEED

Upon activation, platelets secrete serotonin (5-HT), enhancing the response to other agonists.



Detection of serotonin in whole blood or *in vivo* has diagnostic value for risk assessment.

PROBLEM

Current methods to detect 5-HT are limited:

- Real-time tracking
- *In vivo* detection
- Sample preparation

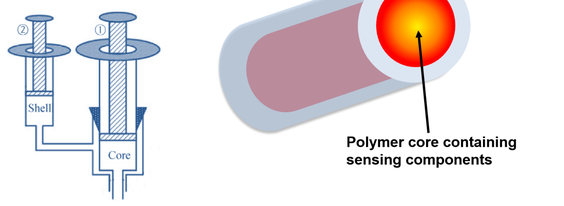
Nanofiber scaffolds provide solutions:

- Quantitative monitoring in real time
- No complex sample preparation
- Injectable biocompatible components

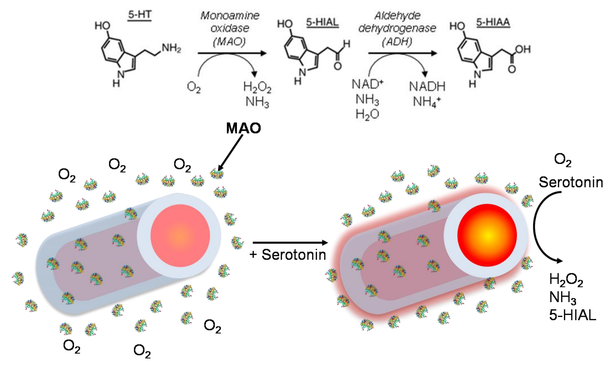
APPARATUS

Coaxial electrospinning:

- Polymer core
- Collagen Shell



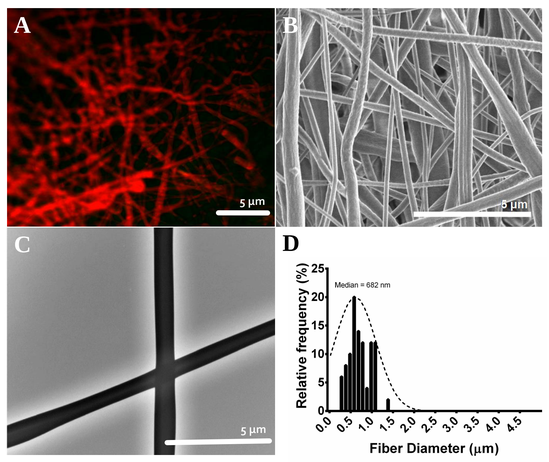
APPROACH



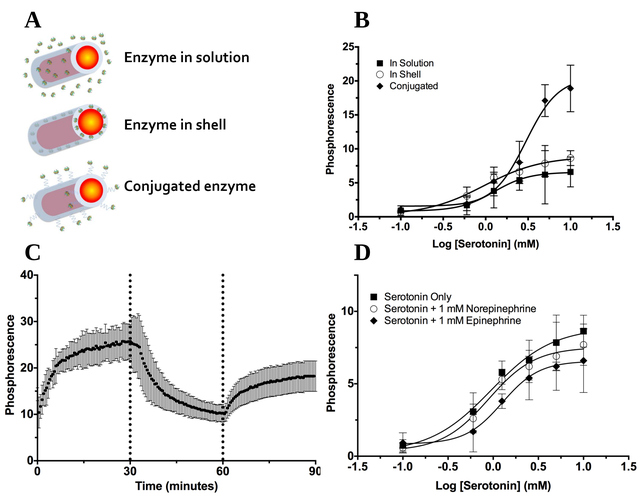
Mechanism:

- Monoamine oxidase (MAO) coupled to sensors to deplete local oxygen
- Oxygen-sensitive dye signal increases
- Reference dye for quantitative imaging

RESULTS

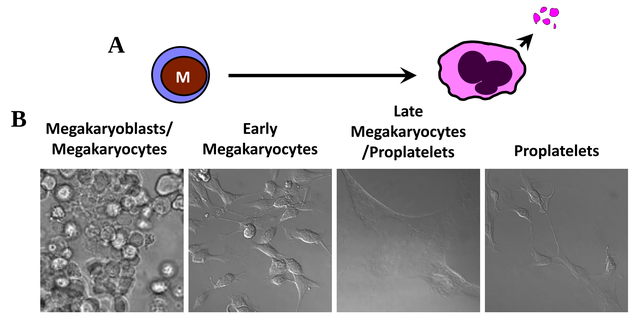


Electrospun serotonin-sensitive scaffolds. (A) Confocal image, (B) SEM image, (C) TEM image, and (D) size distribution.

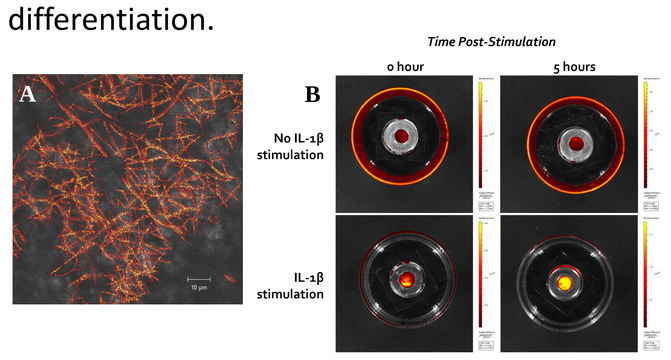


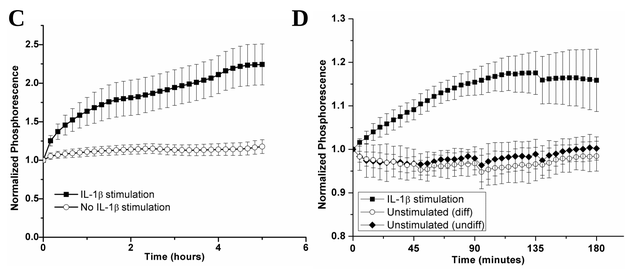
Nanofiber scaffold response to serotonin. (A) Schematic of nanofiber designs, (B) scaffold response, (C) scaffold reversibility, and (D) scaffold selectivity.

RESULTS



Determining an appropriate cellular model. (A) Megakaryoblast differentiation and (B) microscope images of Meg01 cell differentiation.





Nanofiber scaffold response to cellular serotonin. (A) Confocal image of scaffolds with cells grown on them (overlay of experimental and reference dyes), (B) fluorescent reader images of scaffolds, (C) response with Meg01 cells, and (D) response with T33 cells.

CONCLUSIONS

- Nanofiber scaffolds selectively and reversibly detect physiologically-relevant concentrations of serotonin in the presence of enzyme.
- Nanofiber scaffolds can detect physiological concentrations of serotonin released from stimulated megakaryocytes.

ACKNOWLEDGEMENTS

This work was supported by NIH (NIGMS) grant HHS/1R01NS084641-01A1.

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