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DEVELOPMENT OF A SMART HYDROGEL BASED SENSOR FOR MONITORING AND PREVENTING OPIOID OVERDOSE

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Fentanyl is a highly potent opioid that is administered during and after surgery in order to mitigate pain [1]. The correct dosage of fentanyl needed varies from patient to patient and depends on factors such as body mass, pain tolerance, etc. Failure to administer the correct dosage may lead to fatal respiratory depression. To help solve this problem, the goal of this project was to develop a miniature continuous blood fentanyl sensor that can be placed on the catheter used to administer fentanyl during surgery.

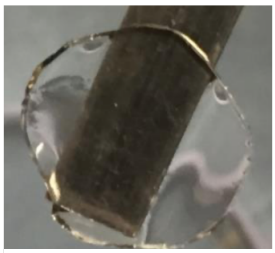

Figure 1: A transparent hydrogel on a metal surface

A continuous fentanyl sensor was designed that contained a "smart" fentanyl-responsive polymer hydrogel. Such a hydrogel is a biocompatible crosslinked polymer network that reversibly swells or shrinks in response to changes in the environmental fentanyl concentration [2]. The hydrogel network was formed by polymerization of three different monomers: acrylamide (AAM), N,N'-methylenebisacrylamide (BIS), and a monomer containing a fentanyl-binding aptamer. The aptamer is a short single strand of DNA with a base pair sequence chosen so that it selectively binds to fentanyl in blood, thereby allowing the fentanyl-sensitive hydrogel (FSH) to respond to changes in fentanyl concentration in the surrounding solution.

A continuous fentanyl sensor can be obtained by combining an FSH with a device for transducing hydrogel response into electrical signals. To detect hydrogel swelling changes, a very thin FSH was deposited on a thin flexible polymer film (polyimide) containing an embedded metallic lead pattern. Hydrogel response to the solution whether swelling or shrinking leads to bending of the multilayer structure, thereby altering the electrical impedance of the leads and giving rise to a measurable electrical signal. This sensor has demonstrated itself to be a potentially cost-effective continuous sensor capable of rapid detection of changes in fentanyl concentration.

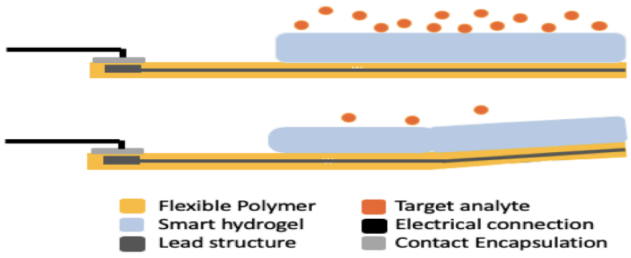

Figure 2: The sensing approach in which fentanyl changes result in bending of a multilayer hydrogel/polymide structure, thereby producing an electrical signal.

References

[1] Bailey PL, Pace NL, Ashburn MA, Moll JW, East KA, Stanley TH, "Frequent hypoxemia and apnea after sedation with midazolam and fentanyl", Anesthesiology 1990; 73(5), 826-830.
[2] Peppas, N. A., Hilt, J. Z., Khademhosseini, A. and Langer, R. (2006), Hydrogels in Biology and Medicine: From Molecular Principles to Bionanotechnology. Adv. Mater., 18: 1345–1360. doi:10.1002/adma.200501612