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Development of a Novel Fiber Optic Sensor Combined with a Fluorescence Turn-on Probe for Cu (II) Detection

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Abstract. Existing staining-based methodology for the detection of metal ions is not well suited for real-time or in situ use. This is a significant problem, given that these ions can have a considerable impact on both human health and the environment. Thus, there is growing interest and need for simple, rapid and in-situ monitoring techniques for the purpose of detecting various target analytes (e.g. heavy metals), which is of a significant importance in many fields ranging from environmental monitoring to the study of intracellular processes. Among various sensors developed, optical fiber-optic sensors (FOS), based on fluorescence, are one class of sensors that address this goal [1]. Optical fibers are ideal for environmental sensing applications because of their ability to transmit optical signals to and from the sensing region without the use of free-space optics. In this work, we present, for the first time, a simple FOS incorporating novel fluorescence turn-on mechanism [2] that could detect Cu (II) as low as 10^{-4} M. Traditionally, fluorescence quenching or "turn-off" was used to detect Cu (II) [3]. In recent years, fluorescence "turn-on" emerges as a preferable tool. The developed fiber-optic sensor has two fiber leads and one probe head. One fiber lead includes 6 fibers for He-Ne laser excitation light delivery (e-fibers). Another fiber lead has one receiving fiber (r-fiber) connected to an Ocean Optics QE65000 scientific grade spectrometer, which is interrogated by a computer via USB connection. The SpectroSuite software is used to observe and to record all spectra. The probe head combines all fibers together to form a coaxial structure with the r-fiber placed in the center. The key component in the proposed fluorescent sensing system is a probe prepared by binding a receptor containing a zwitterionic chromophore (M1), through noncovalent interactions, to the fluorescent polymer (P1) resulting in quenching its emission. The sensing mechanism involves the release of P1 (a fluorescent indicator) from its non-fluorescent indicator/receptor (P1/M1) pair upon exposure to Cu (II). The zwitterionic chromophore (M1) was found to show high selectivity and sensitivity to Cu (II), making it an ideal receptor for the recognition of Cu (II) [4]. The optimum operating conditions and performance characteristics for the new sensor will be discussed.

Key words: fiber optic sensor, fluorescence turn-on probe, copper

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References

Ma, J.; Chiniforooshan, Y.; Hao, W. H.; Bock, W. J.; Wang, Z. Y. "Easily fabricated, robust fiber-optic probe for weak fluorescence detection: modeling and initial experimental evaluation", *Optics Express,* 2012, *20*, 4805-4811.

Ma, J.; Hao,W. H.; Chiniforooshan, Y.; Bock, W. J.; Wang, Z. Y. "Easily Fabricated, Robust Fiber-optic Probe for Weak Fluorescence Detection Part II: "Off-on" Titration of Trace Heavy Metal" (In preparation)

D. R. Shnek, D. W. Pack, F. H. Arnold, and D. Y. Sasaki, "Metal-induced dispersion of lipid aggregates: a simple, selective, and sensitive fluorescent metal ion sensor" *Angew. Chem*., Int. Ed. Engl., 1995*, 34*, 905-907;

R. Krämer, "Fluorescent chemosensors for Cu^{2+} ions: fast, selective, and highly sensitive" *Angew. Chem., Int.* Ed., 1998, *37*, 772-773;

A. Torrado, G. K. Walkup and B. Imperiali, "Exploiting polypeptide motifs for the design of selective Cu (II) ion chemosensors," *J. Am. Chem. Soc*., 1998, *120*, 609-610;

P. Grandini, F. Mancin, P. Tecilla, P. Scrimin and U. Tonellato, "Exploiting the self-assembly strategy for the design of selective Cu^{II} ion chemosensors", *Angew. Chem.,* Int. Ed., 1999, *38*, 3061-3064.

Hao, W. H.; McBride, A.; McBride, S.; Wang, Z. Y. "Colorimetric and near-infrared fluorescence turn-on molecular probe for selective detection of cysteine in human plasma", *J. Mater.Chem.,* 2011, *21*, 1040.