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Characterization of Optical Fiber Dissolved Oxygen Sensor for aquaculture sensing and monitoring

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Abstract

Optical fiber sensor using sol gel membrane incorporated RTV silicon rubber was fabricated and developed for the characterization of dissolved oxygen in aqueous solution. The sol gel materials used consists of Tetraethylorthosilicate (TEOS) and Triethoxyoctylsilane (Octyl-triEOS) as the precursor compound for the preparation of the sol gel structures, while tris-BP Ruthenium (II) chloride as the fluorescent lifetime of the oxygen indicator. Dip coating techniques is utilized to position the sol gel technology at the distal end of the optical fiber. Dissolved oxygen gas sensor characterizations include a study on the sensitivity, temperature effects and drift rate of the sensor performance when measured in 40ppt salt water. Potential applications of the optical fiber sensor are including aquaculture, river monitoring and environment sector.

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Keywords: Dissolved oxygen sensor, optical sensor, sol gel, fluorescence

1. Introduction

Study shows that the selection of the sol-gel precursor compound found to be critical in the performance of optical sensor [1], with the entrapment of chemical indicator. Sol gel offers important advantages over other supports as for instance, chemical inertness, high thermal stability, excellent optical transparency, high physical intensity and triplet lifetime of the immobilized probe [2]. In this study we

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investigate the sensitivity and drift rate of the optical fiber DO sensor. The sensor described was based on fluorescence method. Sensing principles of fiber optic oxygen sensor have been described elsewhere [3].

2. Material and Methods

Sol-gel solutions were prepared in dark vial by adding 4ml TEOS to 40µl Octyl-triEOS. This was followed by 1.25ml ethanol and 400µl 0.1M hydrochloric acid with the mixture being stirred at 500rpm for 1 hour to enable complete dispersion of the indicator molecules in the sol-gel solution. Later, 35mg of ruthenium complex purchased from American Elements, with the addition of 10ml ethanol is separately prepared. The mixture is stirred at 250rpm for 1hour. Upon process completion, both solution are blend together and stirred at 250rpm for 30minutes. The sol-gel solution was stored at room temperature and was usable for up to 3 weeks before a new solution had to be prepared due to the onset of gelation. Prior to this issue, the sol-gel solution need to be stirred at 200rpm before usage.

Next, about 680mg RTV silicon rubber is prepared and diluted using 3ml THF. The solution is shakes continuously until homogenous mixture is obtained.

The sol-gel solution and RTV silicon rubber was applied to the distal end of optical fiber through dip-coating techniques. The sensor probe geometrical construction is shows in Figure 1.

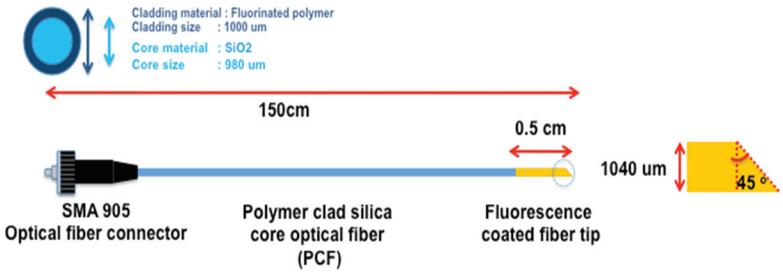

Fig. 1: Optical DO sensor probe geometrical construction

Prior to coating, the end of the fiber is cut at 45° angle and polished using abrasive paper. After cleaning and drying, KSV NIMA dip coater instrument is used to dip the fiber tip into the sol-gel and RTV solutions. Design of experiment, DOE to determine the optimum withdrawal rate for sol-gel and RTV coating is performed through Minitab software. 2-level full factorial design was chosen to run the DOE. Sol-gel withdrawal rates in the range of 80mm/min and RTV 200mm/min were found suitable to form coating on fibers and to yield acceptable fluorescent signals. The fibers next went for 1 day curing process at room temperature before baked in 70°C oven for 24hours. Later, RTV is coated using withdrawal rate of 200mm/min and dried at room temperature for 24hours.

The experimental set-up used is as Figure 2. Measurement on phase difference, sensitivity and linearity are done at DO level (%) of 100, 75, 50 and 20. Characterization for temperature effects took place at 10, 25, 40 °C cycles with all sensors were continuously soak in 40ppt salt water.