Determination of Trace Water Content in 1,4-dioxane Base on Fluorescence Intensity of Umbelliferone in Presence of Silica Nanoparticles

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In many organic solvents, water is generally considered as an impurity, and therefore its measurement in solvents is of importance for many industries and technologies. 1,4-dioxane is a cyclic diether forming a sixmembered ring that frequently used as a solvent in the formulation of inks, coatings, and adhesives, and as solvent for extracting animal and vegetable oils [1]. In the laboratory, 1,4-dioxane is useful as solvent for high-performance liquid chromatographic and a cryoscopic solvent for molecular mass determinations, as a stable reaction medium for diverse reactions. The largest single use of 1,4-dioxane is the stabilization of 1,1,1-trichloroethane against chemical attack by aluminum [2].

The traditional method for the quantitative measurement of water in organic solvents is the Karl-Fisher titration. Although this method has been modified and improved [3], some disadvantages still exist such as slow reaction rate, requirement of personal skill of the analyst, interference from other contaminants which limit the application of the method.

Coumarines are compounds originating from nature that can be used in industry: they are broadly used in cosmetics, food and drinks as a flavoring. Umbelliferone or 7-hydroxy coumarin is one of the most important members of coumarin families. The chemical structure of Umbelliferone is shown in as follows:

\[
\text{HO} \quad \text{O} \quad \text{NO} 
\]

The experimental response curve of the probe for water content in 1,4-dioxane was investigated. The small portion of Silica nanoparticles is applied to the system to improve linear response of Umbelliferone [4]. It is experimentally observed that with increasing of water content, the Umbelliferone fluorescence intensity in presence of nano silica changed dramatically and showed lower intensity at 410–430 nm quenching region (when add 0.00 to 1.00 % (v/v) of water) and higher intensity at 435–450 nm enhancing region (when add 1.00 to 3.00 % (v/v) of water) as compared to pure 1,4-dioxane solution of Umbelliferone in presence of nano silica. The following equation was obtained by fitting the experimental data:

\[
\begin{align*}
\text{Quenching region (0.00 to 1.00 % (v/v) for water)}: & \quad I = 0.8274[H_2O] + 1.0033 \quad (R = 0.99) \\
\text{Enhancing region (1.00 to 3.00% (v/v) for water)}: & \quad I = 4.5617[H_2O] - 4.7789 \quad (R = 0.99)
\end{align*}
\]

In conclusion, the successful fabrication of the proposed probe presented satisfactory sensitivity and low detection limits and is a useful example of the use of Coumarines derivatives for fluorescence probes to detect water.

REFERENCES