A laser fluorosensor integrable into a hyperspectral multisensor system for the analysis and detection of oil spills

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Abstract

This work presents one part of the activities that are being carried out in the framework of the VEM2003-20088-C04-03 project entitled "Development of a hyperspectral sensor and complementary optical techniques for teledetection and analysis of marine oil spills". The aim is to determine fluorescence spectra of seawater samples taken from coastal areas of the Galician Estuaries (Rías Galegas) with and without oil spills. These fluorescence data will be useful to develop a laser fluorosensor which can be integrated into a smart hyperspectral multisensor or it can be used independently for diagnostic purposes of oil pollution samples. When it is used within a hyperspectral multisensor then an intelligent processing of fluorescence images could be made, which could avoid the main limitations related to the overlapping between the fluorescence spectral bands of oil and aquatic humic substances. We present the main characteristics of the instrument, the method used and several preliminary results about oil fluorescence measurements made in laboratory experiments.

Introduction

- Monitoring of oil pollution in marine waters remains a topical issue, which is especially relevant in coastal sea areas because of the adverse consequences on the marine ecosystem.
- The development of new methods and techniques of detection, analysis and quantification of oil pollution, or the adaptation of wellknown techniques to determinate geographical areas is being a extremely important task of environmental protection.
- Within the framework of the project VEM2003-20088-C04-03 (Grant of the Ministry of Education and Science, Spain) (and PGIDIT04PXIC22201PN, Grant of Xunta de Galicia), several activities are being carried out related to the instrumental part of a hyperspectral multisensor system, that is:
  1. The design and construction of a lightweight hyperspectral imager to be used as a passive sensor.
  2. The study of fluorescence spectra of samples of oils and oily seawater (in order to both obtain a fluorescence spectra database and an active sensor).
- One of the primary aims will be to check the possibility to integrate a possible active laser fluorosensor into the hyperspectral multisensor system (see figure 1), which could made an intelligent processing of both the natural and fluorescence images through different artificial network techniques [1, 2].

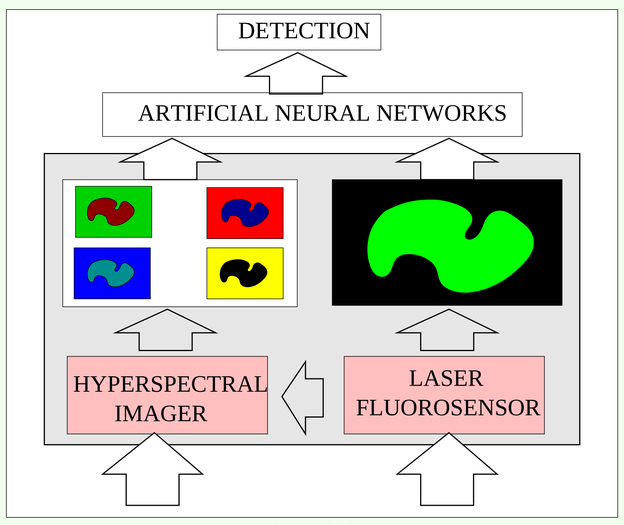


Figure 1: Hyperspectral and fluorescence multisensor for detection of oil spills measurements

- Laser fluorosensors are active sensor since they provide their own source of excitation allowing their operation as well during full daylight as it does at night [3].
- These active sensors take advantage of the fact that certain compounds in oil spills absorb ultraviolet light and become electronically excited, in such a way that process of fluorescence emission is produced primarly in the visible region of the electromagnetic spectrum (see figure 2).
- Different classes of oil exhibit characteristic fluorescence spectral signatures.
- Analysis and/or detection in situ and/or teledetection of oil spills in the seawater (by including intelligent processing) require a large spectral information about the seawater fluorescence of a particular geographical area and the influence of oil pollution on these spectra.
- In short, the aim of this work will be to contribute to the analysis of the spatial distribution of the natural fluorescing components of the seawater in the surface layer of the Galician Estuaries, and to investigate the influence of the oil pollution on seawater fluorescence.

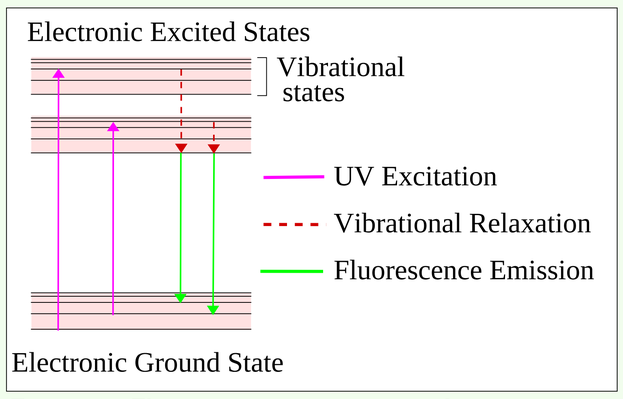


Figure 2: Fluorescence excitation and emission process.

Setup and preliminary results

- A Nitrogen Laser (NL) and a fibre optic spectrometer, for the 250-850nm spectral region and with resolution 0.5nm, are being used to obtain preliminary fluorescence spectra of oil samples.
- The UV excitation of the NL source (337.1nm) has been used and fluorescence spectra have been obtained for analysis 3-(A) and teledetection 3-(B) purposes.

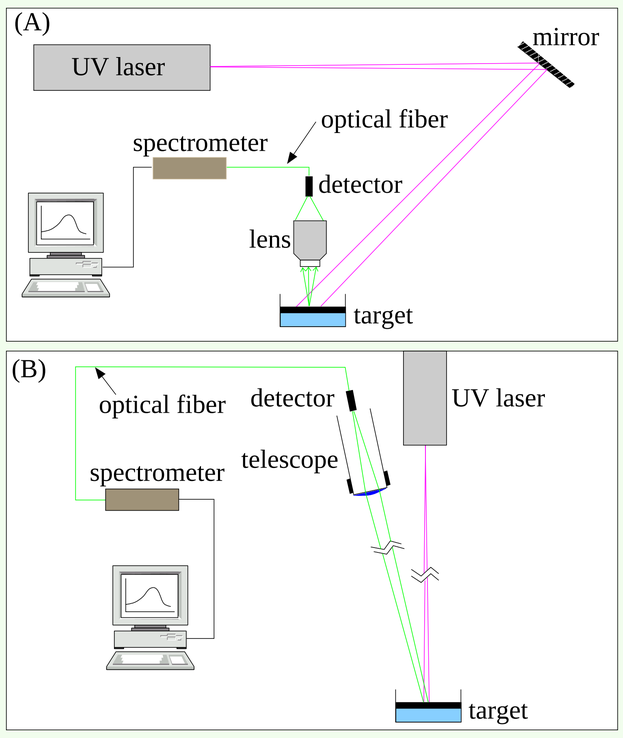
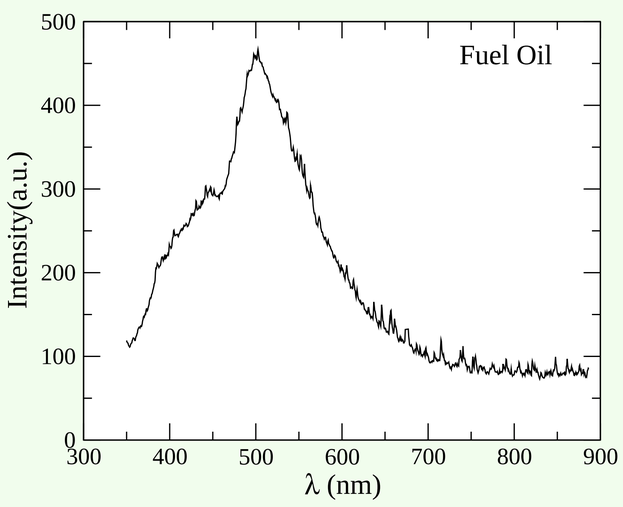
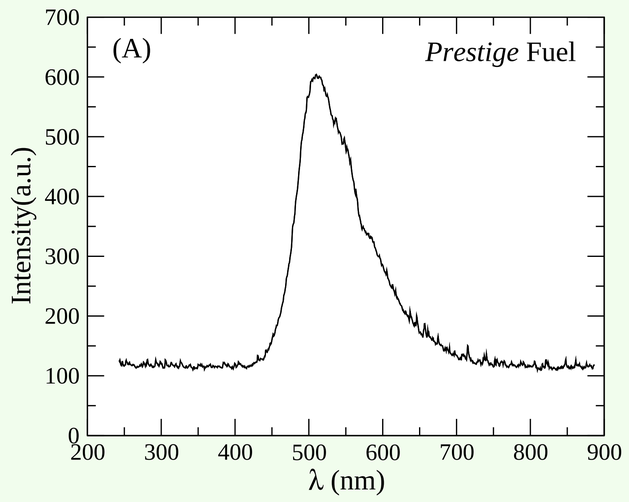


Figure 3: Setups for the fluorescence measurements.

- Samples of fuel oil [4], *Prestige* fuel [5] (in acetone solution) and commercial lubricant oil have been spilled on the free surface of seawater and their fluorescence spectrum have been registered. In both cases the telescopic and analysis configurations, a relevant fluorescence efficiency (see figures 4-(A), (B) and (C)) is observed which confirms the wellknown powerful of the fluorosensing method.





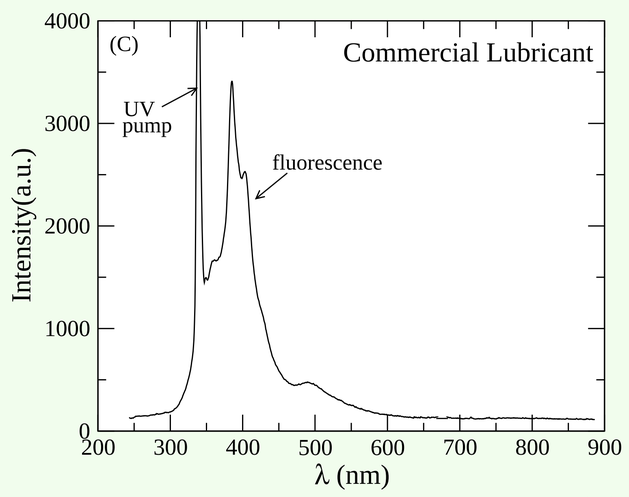


Figure 4: Laser-induced spectra of Prestige fuel (A), Fuel oil (B) and commercial lubricant (C).

Discussion

- According to the results obtained above, the next task we will to study the variations in the form and intensity of different oils fluorescence spectra and later to assess the effect of oil in the surface water. With these results a database can be constructed to be used for both analysis purposes of oil pollution in the laboratory and intelligent processing by the hyperspectral multisensor.
- In conclusion, one of the possible complementary active sensors candidate to be added to the multisensor system will be a laser fluorosensor. The aim is that these fluorosensing techniques and results can be integrated into the hyperspectral multisensor for processing fluorescence images by means of the unsupervised classification and analysis approach proposed in the coordinated project VEM2003-20088-C04-03.

Acknowledgments

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References

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[2] Dolenko, T. A., Fadeev, V. V., Gerdova, I. V., Dolenko, S. A. and Reuter, R. (2002). *Fluorescence diagnostic of oil pollution in coastal marine waters by use of artificial neural networks*. Appl. Opt. Vol.41, pp.5155,5166.

[3] Brown, C. E. and Fingas, M. F. (2003). *Review of the development of laser fluorosensors for oil spill application.* Marine Pollution Bulletin, Vol.47, pp.477-484.

[4] The sample of fuel oil has been provided by the Vigo Oceanographic Centre.

[5] The original *Prestige* oil was recovered in Quilmas beach (northside of Carnota beach) by one of the authors.