Double clad fiber probe for fluorescence spectroscopy

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Abstract

We report a probe using a single double clad fiber (DCF) for fluorescence spectroscopy. Bidirectional separate transmission for excitation and fluorescence light in a single fiber was implemented. A DCF coupler made by side-polished method could extract none but the collected fluorescence signals propagating in inner cladding mode, thereby diminishing the interference of silica background generated by the excitation in core mode. The experimental results show that the fluorescence spectra of biological tissues obtained using the DCF probes have much less silica background than using a standard multiple-mode fiber.

Introduction

Fluorescence spectroscopy has become an attractive technique for non-invasive, *in vivo* specific analyte examinations, and been widely used in many fields such as biomedicine and chemical engineering [1-2]. The fluorescence spectroscopy system is usually composed of light sources, spectrometers, and fiber optic probes for light delivery and collection. The versatile interface between instrument and tissue provided by fiber-optic probes enables the remote fluorescence detection.

A variety of fiber-optic probes for fluorescence spectroscopy have been reported and well summarized in Ref [3]. Commercial silica fibers are usually employed in probes as light transport conduits. According to the function of fibers, current probes are of two types, single-fiber and multiple-fiber probes. Single-fiber probes use the same fiber to deliver excitation light and collect fluorescence signals, while multiple-fiber probes use different fibers. Single fiber probes have advantages of smaller form factor, simpler configuration and lower factory cost than multiple-fiber probes. However, the background generated by the fiber itself dominates the measured spectra using a single fiber, thereby making it difficult to discern the fluorescence spectrum of the sample of interest. As a result, multiple-fiber rather than single-fiber probes are adopted in most practical applications, because a solution of separate illumination-collection channel can minimize the effect of the background [3].

We report a probe using a single DCF for fluorescence spectroscopy, in which the excitation and the fluorescence light propagates in core-mode and cladding–mode, respectively.

Experiments and results

Fig.1(a) shows the optical system for fluorescence spectroscopy with a single DCF probe. We measured the fluorescence spectra of fresh gingko leaves whose red and far-red fluorescence emissions are remote from the silica background under 488nm excitation. Fig.3 (a) shows the fluorescence spectrum obtained using the DCF probe. Two peaks lying nearly at 685nm and 740nm are inherent in Chlorophyll *a* of the antenna system of photosystem Ⅱ[4]. For

comparison, a single MMF probe system as that depicted in Fig.1 (b) of Ref.[3], as well as a direct-pump configuration system as shown in Fig.3 (e) was designed for fluorescence measurements, respectively. In the direct-pump configuration, a laser beam was directly incident on a sample at an angle of 30° with respective to the normal and the fluorescence light was collected by a MMF placed above the illuminated spot. The same standard silica MMF with 3.0m length and 50μm-core-diameter was alternately used in both experiments. Figs.3 (b) and (c) show the spectra obtained using the single MMF probe and the direct-pump configuration, respectively. The laser power at the sample was 10mW for the direct-pump configuration and 5mW for the others. Each spectrum had an acquisition time of 1.0s and was normalized to the mean intensity in the wavelength 500-800nm.

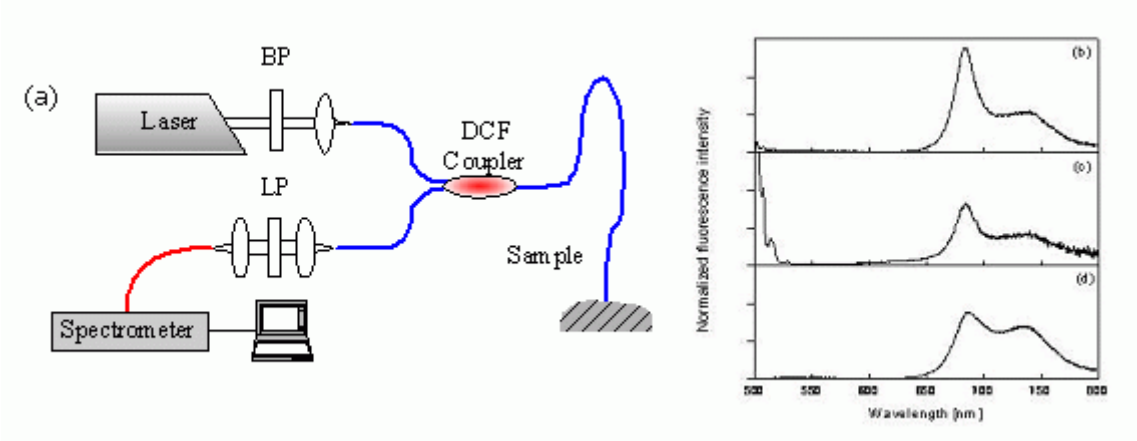

Fig. 1. (a) Schematic of the optical system for fluorescence spectroscopy with a single DCF probe. Normalized fluorescence spectra of a fresh gingko leaf under 488nm excitation obtained using a (a) DCF probe, (b) single MMF probe, (c) direct-pump configuration.

Conclusion

A fluorescence spectroscopy system using a single double clad fiber have been designed, established and evaluated. The interference of silica background on fluorescence spectroscopy was successfully diminished.

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References

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