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Carbon dots as a dual sensor for the selective determination of D-penicillamine and biological applications

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ABSTRACT

Dual mode Nanosensors gained tremendous interest in recent years because of their facile synthesis and dual applications. Herein we have synthesized highly fluorescent carbon dots (CDs) from Mahogany fruit shell by chemical oxidation method. The as prepared CDs exhibited selective and sensitive quenching of fluorescence by Fe^{3+} and also accompanied by a dramatic increase in absorption intensity. Hence these two processes led to fabricate CDs-Fe^{3+} system as a dual probe. D-Penicillamine (D-PA) has much affinity toward Fe^{3+} which resulted in recovery of almost 75% fluorescence intensity and decrease in absorption of the CDs-Fe^{3+} system. Thus, this tendency has been exploited for the selective detection of D-PA by both Spectrofluorimetrically and UV-Visible spectroscopically and showed a wide linear range of detection 0-48 μg mL^{-1} and 0-40 μg mL^{-1} respectively. This developed probe offered low cost, high selectivity, repeatability, facile operation and excellent recovery ratio in detection of D-PA in pharmaceutical samples. Moreover, biological applications CDs were investigated using *Saccharomyces cerevisiae* strain with confocal microscopy. We found that CDs were a biocompatible and ideal candidate for differential staining of yeast cells.

1. Introduction

Penicillamine (3,3-dimethylcysteine) is a hydrolytic degradation product of penicillin. It has an alpha-amine, a carboxyl and sulfhydryl functional groups which largely determine its pharmacological effects. It is low molecular weight, pharmaceutical significant sulfur containing chiral amino acid which has enticed in recent years owing to their therapeutic applications and having mighty chelating ability with heavy metal ions [1]. Generally, it has D and L enantiomeric form which has different biological and toxicological properties. Levorotatory Penicillamine (L-PA) isomer is a pyridoxine antagonist and extremely toxic and even small dose can causes adverse effects while D-Penicillamine (D-PA) is a clinically useful isomer [2]. D-PA has been widely used as a therapeutic agent in various diseases; one of them is a Wilson's disease, a genetic disease that results in excessive copper deposits in the body tissues [3,4]. It is also used as antirheumatic drug to treat rheumatoid arthritis [5]. Along with this, D-PA finds applications as a potential drug in scleroderma, primary biliary cirrhosis, cystinuria, liver disease and heavy metal poisoning [6]. It is also quickly absorbed in the gastrointestinal tract and is rapidly oxidized to various disulphide forms [7]. However, this sulfhydryl drug also induces numerous side-effects, including myasthenia gravis, ageusia or dysgeusia rash, thrombocytopenia, pemphigus, agranulocytosis, polymyositis, proteinuria, or hypersensitivity nephritic syndrome [2,8,9]. Thus D-PA not only acts as a biological but also pharmaceutical significant medication concerned to human health. Hence, it is essential to monitor the concentrations of these compounds in biological fluids as well as in pharmaceuticals samples.

Till date, there are many attempts have been carried out for the determination of D-PA in pharmaceutical preparation and biological samples by using various analytical methods. These are high performance liquid chromatography (HPLC) [10,11], colorimetry, Spectrophotometry [12,13], voltammetry/electrochemical sensor [14,15], flow injection analysis [16,17], capillary electrophoresis [18], chemiluminescence [19]and electrochemistry [20]. Although these methods found to be suitable for quantification of D-PA, some of them undergo interference from the pharmaceutical or biological matrix while others are time consuming and require expensive equipment and, as a result,

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