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Nanoparticle-based paper sensor for thiols evaluation in human skin

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Abstract

A new sensitive non-invasive gold nanoparticle-based sensor that enables to detect thiols in the human skin has been developed. The detection procedure implied the assessment of the color change of a paper sensor resulting from aggregation of gold nanoparticles caused by thiols. The ratio of the intensity of the photo image blue channel vs the red one (in units of RGB coloration) served as analytical response. The main thiol in the skin is glutathione, therefore, it was used as model biothiol and spiking substance. The range of linearity for glutathione was 8 - 75 μM, the detection limit - 6.9 μM. RSD≤7% is for inter-day determination of 10 μM glutathione and RSD≤12% is the intra-day value. The recovery of 5 μM and 10 μM of glutathione was evaluated by applying solution, containing thiol-spikes, on skin. The results varied in the range 77 - 138 %. A hundred-fold excess of serine, alanine, histidine, threonine, creatinine, urea, and ammonia; a ten-fold excess of glycine, proline, leucine, isoleucine, phenylalanine, asparagine; and a five-fold excess of valine, tryptophan, tyrosine, and uric acid, which can be extracted from the skin and is contained in the test matrix, have no significant effect on 10 μM glutathione signal. Thiols level in the skin of volunteers (21-65 years old, men and women) detected with the use of a proposed non-invasive sensor was 11.6 – 47.5 μM.

Keywords

Paper sensor, gold nanoparticles, thiols, human skin

1. Introduction

Low molecular weight non-protein thiols (e.g., cysteine and glutathione) are important physiological components of human and animal organisms. They play an essential role in maintaining the redox potential of the cell in balance [1]. The important role of thiol-disulphide ratio for healthy or pathological state is described mainly in the series of Erel works [2, 3, 4]. The thiol-disulphide system GSH/GSSG can be regarded as a ‘redox buffer’ [5]. It has been proved that deviation from normal thiol-disulfide homeostasis can lead to the disruption of physiological functions, e.g., heart and neurological diseases [6, 7]. It can also inform about the degree of oxidative stress in the body [8, 9]. Important results for clinical therapy have been obtained while examining patients in critical conditions [10]. Only invasive methods, in which venous blood is analysed, are described [11-13].

In the modern world, there is a growing need for rapid chemical test methods of analysis that could be performed *in-situ* and *on-site*. These analytical problems can be solved with the use of test systems, which are simple, portable, lightweight and cheap [14]. Unique properties of nanoparticles that enable to design highly sensitive, cheap and very small analytical systems generate considerable recent research interest.