Utilization of nanomaterials in detection of food contaminants

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Nanometer scaled materials has been frequently used in the development of novel analysis methods due to their high surface area/volume ratios and size dependent electrical and optical properties. Especially, nanotubes and nanoparticles enable the development of new strategies to achieve high sensitivity, stability and selectivity in bioassay and biosensor systems. Recent developments in nanotechnology applications have aroused interest in the field of food as well as in many different areas, and the research has focused on the use of these applications in the maintenance of food safety. Rapid, reliable and sensitive detection of microbiological and chemical contaminants in food plays critical role in the prevention of foodborne illnesses. Advanced laboratory equipment and specialized staff are required for the analysis of various food contaminants. For this reason only limited number of samples can be analyzed. Hence, development of novel methods is an urgent requirement for food analysis. Novel nanomaterial based methods have the feature of high sensitivity as well as ease of use and in-situ detection. In these methods, nanomaterials are used as catalytic agents, platforms for the immobilization of recognizing agent, optical or electroactive labels. By coupling different biological recognition molecules such as enzymes, antibodies or aptamers with nanomaterials, it is possible to detect important agents of foodborne diseases such as pathogenic bacteria, viruses and toxins. Nanomaterials significantly enhance the performance of electrochemical biosensors. Due to the optical properties of semiconductor nanoparticles, sensitive and multiplex detection of food contaminants can be achieved by fluorometric analysis. Besides, it is possible to carry out in-situ analysis by paper based methods in which nanoparticles are used. New strategies can be developed in terms of quality control and traceability in the food industry by these bioassays.

The development of sensitive, reliable, inexpensive and portable detection systems by nanomaterial integrated bioassays and biosensors have become a popular research topic. Although the detections of various food contaminants have been successfully performed on model systems, the same success could not be achieved when working with real samples. The variability in the structure of the samples and the reproducibility problems limit the use of these developed systems in food analysis. In order to use these developed methods effectively in real food samples, it is necessary to increase the stability and minimize the interference caused by the real sample. In this respect, although pretreatment steps including the extraction of the target analytes are developed, they prolong the analysis time of the method and obstruct the in-situ detection. By ensuring the automation of analysis method and integrating extraction into the system, an important step about the use of these developed systems in food analysis will be attained. Besides, with the widespread use of these systems, the potential toxicity problem due to the nanomaterials should also be investigated. By removing these obstacles in future studies, it will be possible to use the nanomaterial based detection systems in food analysis.
In our research group, we have developed a novel method for the detection of Escherichia coli in water samples by coupling immunomagnetic separation with semiconductor nanoparticle lebeling (Dudak and Boyacı, 2008). We have also demonstrated the capability of semiconductor nanoparticles in the multiplex detection of bacteria (Dudak ve Boyacı, 2009).

A SERS-based analysis method for the determination of Staphylococcal enterotoxin B was developed using core-shell structured iron-gold magnetic nanoparticles and the performance of the developed system in milk, serum and urine samples was examined (Temur et al., 2012). In addition, a significant enhancement in the analytical sensitivity for target analytes has been demonstrated in the studies where gold nanorods were used as SERS labels (Güven et al., 2014; Torul et al., 2014).

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