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Photoacoustic Determination of Iron in Corn Meal

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We report here on the use of the photoacoustic technique for the determination of low concentrations of total iron in corn meal samples. The determination of this element in food is of considerable interest because several foods are currently enriched with it at proper levels in order to increase the resistance of people, after consumation, to several diseases, such as anemia. The proposed technique is based on an open photoacoustic cell configuration in conjunction with a suitable colorimetric method. We applied it to a measurement of the total iron concentration in corn meal samples. The results agree very well with those obtained using a conventional spectrophotometric method, showing the possibilities of new experimental methodologies based on photothermal methods to perform this kind of study, with the advantage of a higher sensitivity and increment of the range of appreciable absorbance.

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Introduction

Anemia caused by iron deficiency is the most important nutritional problem, affecting mostly the low socio-economic populations of the developing world. The fortification of foods, such as cereals, with iron has been recognized as a worldwide necessity, since a deficiency of this element produces different metabolic disorders.[1] Therefore, the development of methods to measure low concentrations in foods has become of increasing importance.

In order to achieve higher sensitivity and selectivity than those of the traditional optical spectroscopic methods, the use of photothermal (PT) techniques is advantageous. These techniques include a group of high-sensitivity methods[2] based on a photoinduced periodical change in the thermal state of a sample. Light energy which is absorbed and not lost by reemission leads to sample heating, which induces changes in the temperature-dependent sample parameters. The detection of these changes is the basis of the different experimental possibilities. Among them, open photoacoustic (PA) techniques[3] are especially suitable for spectroscopic studies of strongly absorbing chromofores liquids. Compared to the conventional PA technique, they offer some attractive features. First, the requirement for accommodating the sample in a sealed cell is no longer a process, and manipulation (loading and replacing) of the sample is simple to perform. In addition, the signal remains unaffected by a thermal expansion of the sample.[4,5] Finally, as long as it exceeds the sample thermal-diffusion length (μ_s which is the distance at which the amplitude of the PA signal decays to $1/e = 0.368$ of its initial value), the thickness of the sample is not relevant, making the technique more practical for quantitative analysis. On the other hand, in conventional optical spectrophotometry, the values of the absorbance normally range between 0.1 and 1. Since the absorbance is proportional to the optical absorption coefficient, the range of detection of this parameter is limited. The open-cell PA configurations overcome this restriction due to the fact that the thermal-diffusion length in the sample can be modified by properly choosing the light-modulation frequency. In a recent paper,[6] we reported on a microphone-based open PA cell especially designed for spectroscopic measurements in liquid systems. Its usefullnes was demostrated by the determination of Cr(VI) in water in conjunction with a well-known colorimetric method, among other applications.

The objective of the present work is to apply the above-mentioned technique to the determination of total iron in corn meal samples. The determination of this element in food is currently of considerable interest due to its use, when it is added to foods in properly concentrations, to increase the resistance of people to diseases, such as anemia. In the next section we describe the theoretical basis of the proposed method and an specially designed PA cell, which is also suitable for spectroscopic studies of liquid samples. Experimental details concerning our measurement system are also given. The results of measurements performed in calibration samples prepared using a well-established colorimetric procedure are presented, as well as the results of measurements in corn meal samples. They are compared with results obtained by optical spectrophotometry, showing a good agreement.

Experimental Set-up and Method

The proposed experimental set-up is schematically shown in Fig. 1. A monochromatic light beam of known wavelength (for

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