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RESEARCH ARTICLE

Preconcentration of Sunset Yellow Dye Using *β*-Cyclodextrin Butanediol Diglycidyl Ether Polymer as the Solid Phase Extractant

RUPINDER KAUR* and USHA GUPTA

Department of Chemistry, Punjabi University, Patiala, Punjab, India
rupimphil@yahoo.com

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Abstract: A method has been developed for the preconcentration of trace amounts of sunset yellow dye using a newly synthesized *β*-cyclodextrin butanediol diglycidyl ether polymer (*β*-CDP). Various parameters such as effect of pH, sample volume, shaking time, agitation time, amount of adsorbent for the % uptake of the sunset yellow have been optimized. *β*-CDP could be used repeatedly and offered a better recovery of sunset yellow. The method has been for the determination of sunset yellow in different food samples.

Keywords: *β*-Cyclodextrin 1,4-butanediol diglycidyl ether polymer, Sunset yellow dye, Preconcentration, Spectrophotometry

Introduction

Synthetic dyes are widely used for improving the color and enhancing the visual aesthetic appeal of some foods and this effect is maintained throughout the production process and during storage. They present high stability to light, oxygen and pH changes and have lower prices compared to natural dyes[1,2]. Sunset yellow dye is widely used as additives in soft drinks and other food samples. The use of synthetic dyes is strictly controlled by laws, regulations and acceptable daily intake (ADI) values. The allowable limit for sunset yellow mainly used in non-alcoholic beverages and the ADI values are 0 and 2.5 mg kg^{-1}. Dye can cause adverse toxicological effects, being considered as unhealthily substances for humans[3]. Analytical techniques such as spectrophotometry[4-7], column solid-phase extraction[8], derivative spectrophotometry[9], HPLC[10], kinetic determination[11], second derivative spectrophotometry[12], adsorptive stripping voltammetric[13]. Some of the above methods are very costly and required the expert hands. So, spectrophotometry is widely used for the determination of dyes due to its higher sensitivity, low cost, low interference level and its excellent detection limits. So, sunset yellow dye has been determined by spectrophotometric methods after preconcentration using *β*-CDP in food samples.

Supramoleculer complexes with *β*- cyclodextrin has been a very active research field in the past few years[14-16]. *β*- cyclodextrin (*β*-CD) is a very stable oligosaccharide that is composed of seven glucose units linked with each other by *α*-(1,4)-glycosidic linkage. It can form supramoleculer complexes with several organic compounds by incorporating them into their hydrophobic cavities. Two or more *β*-cyclodextrin covalently linked with each other are known as polymers. These *β*- cyclodextrin polymer have been used for the preconcentration of various analytes[17-20]. In the present work, *β*-cyclodextrin 1,4-butanediol diglycidyl ether polymer (*β*-CDP) has been used as a solid support for the preconcentration of sunset yellow dye.

Experimental

A Shimadzu UV-1800 spectrophotometer (Shimadzu Ltd., Japan) equipped with the matched 10 mm quartz cells was used to measure absorbance. Digital century pH-meter C_p -901 with a combined glass electrode was used to carry out pH measurements. A thermostatic shaking water bath (Perfit India Ltd.) was used to carry out all the inclusive procedures.

Reagents

All the chemicals used were of Anal R grade unless otherwise stated. Double distilled water was used throughout the experiment. Brilliant green dye solution was prepared by dissolving 0.482 g in 100 mL of double distilled water to give 0.01 M standard stock solution and further dilutions were made as when required.

20 g of *β*-CD was dissolved in 50 mL of 20% NaOH. To this 20 mL of butanedioldiglcidyl ether was added drop wise. The polymer was formed in 1.5 h and dried at 90 ºC in oven. The polymer was washed with double distilled water 5-6 times. Then, the polymer was dried again at 90 ºC and kept at room temperature in desiccator for further use

Buffer solution in the pH range of 2.0-3.5 were made by mixing equimolar solutions of hydrochloric acid/sodium acetate and buffer solutions in the pH range of 4.0-6.5 were made by mixing equimolar solutions of sodium acetate and acetic acid solutions in the different proportions While those in the pH range of 7.0-11.0 were made by mixing equimolar solutions of ammonia and ammonium chloride. The glass wares were washed with chromic acid and soaked in 5% nitric acid and then cleaned with double distilled water before use and dried in an electric oven.

Procedure

300 mg of *β*-CDP and 2.5 mL of buffer solution (pH 4.0) were added to a 100 mL stoppered conical flask at room temperature. The mixture was allowed to stand for 5 min. 3 mL of dye was added and made up to 90 mL with double distilled water. After the mixture was shaken in the thermostatic shaking water bath for 90 min., 5.0 mL of supernatant solution was transferred into a 10 mL volumetric flask and the absorbance was measured using spectrophotometric method.

Results and Discussion

Optimization of various parameters

Effect of pH

The complexation of the dye with the polymer depends on the pH of the sample solution which was studied in the range of (1.0-7.0.) using different buffer solutions. As it can be seen in Figure 1, % uptake (≥ 95) was obtained at pH 4.0. Therefore, the working pH was chosen as 4.0 for the subsequent studies.

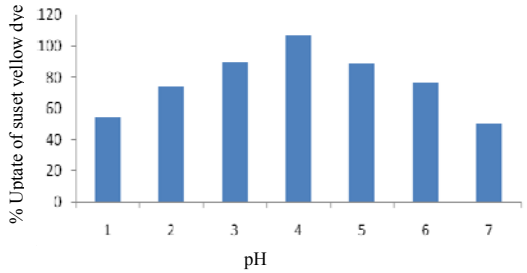

Figure 1. Effect of pH on the % uptake of the sunset yellow dye by the polymer

Effect of shaking time

Shaking time is an important factor in determining the possibility of application of the *β*-CD polymer for the selective uptake of sunset yellow dye. Different shaking time (ranging from 15 to 135 min.) were studied for the % uptake of sunset yellow dye by *β*-CD polymer. The results of % uptake of sunset yellow dye *vs*. the shaking time show that the % uptake of (≥95%) was attained at 90 min (Figure 2). Therefore, the shaking time of 90 min. was selected for further studies.

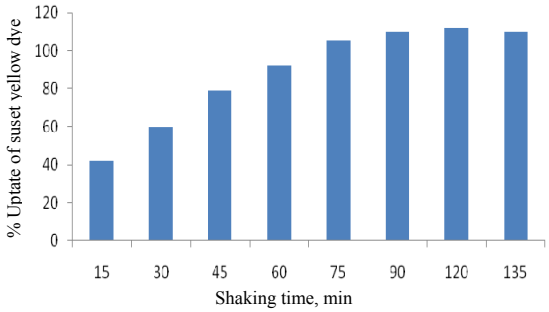

Figure 2. Effect of shaking time on the % uptake of the sunset yellow dye by the polymer

Effect of sample volume

Sample volume is an important factor in determining the possibility of application of polymer for the % of uptake of sunset yellow dye. For this purpose 15, 30, 45, 60, 90 and 105 mL of sample volumes were taken and uptake of sunset yellow dye was studied (Figure 3). The maximum % uptake (≥95%) of sunset yellow dye at sample volume of 90 mL. Therefore, 90 mL of sample volume was used for the further studies.

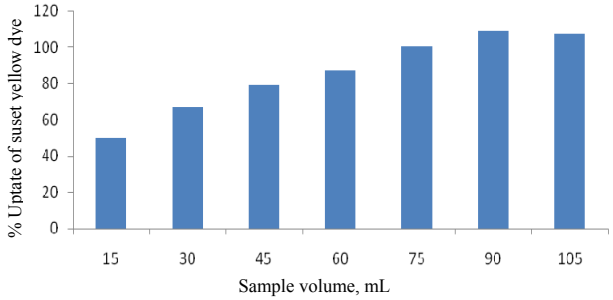

Figure 3. Effect of sample volume on the % uptake of the sunset yellow dye by the polymer

Effect of agitation speed

Speed of shaking is the important factor in determining the possibility of application of polymer for the quantitative % uptake of sunset yellow dye. Different speed (ranging from 40 to 140 r.p.m.) were studied for the % uptake of sunset yellow dye by polymer. The results of % uptake of sunset yellow *vs*. agitation speed (Figure 4) shows that the % uptake reach maximum (≥ 95%) at 140 r.p.m. Therefore, the shaking speed of 140 r.p.m. was selected for the further studies.

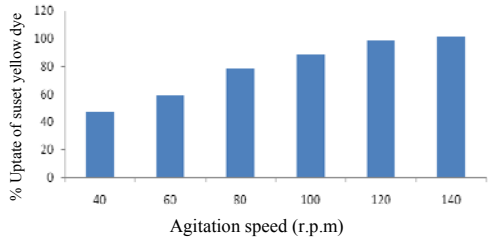

Figure 4. Effect of agitation speed on the % uptake of the sunset yellow dye by the polymer

Effect of amount of polymer

The amount of the *β*-CD polymer is another important parameter that affects % uptake of dye. A quantitative removal (≥ 95%) cannot be achieved when the *β*-CD polymer is less than the optimum amount. In order to optimize the smallest amount of polymer, 100, 200, 300, 400, 500 and 600 mg of the polymer were added to the solution containing known amount of dye. The quantitative recoveries were obtained at 300 mg of *β*-CD shown in (Figure 5). Therefore, 300 mg of the *β*-CD has been used for further studies.

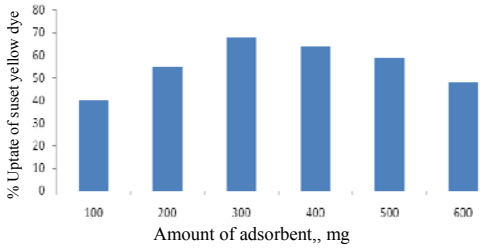

Figure 5. Effect of amount of adsorbent on the % uptake of the sunset yellow by the polymer

Applications

Determination of samples

The proposed method has been applied for the determination of sunset yellow dye in Santra goli and Mirinda. The results are given in Table 1.

Table 1. Result of determination of sunset yellow in food samples

Food samples	Added, ug/mL	Found, ug/mL	Recovery, %
[a]Santra Goli	0	0.020	-
	0.502 ug/mL	0.487 Ug/Ml	97.011%
	1.005 ug/mL	1.01 ug/mL	100.49%
[b]Mirinda	0	0.022	-
	0.502 ug/mL	0.489 ug/mL	97.41%
	1.005 ug/mL	0.993 ug/mL	98.80%

[a]Santra goli - locally available in market, [b]Mirinda - locally available in market

Conclusion

The proposed preconcentration method consist of a simple and low cost procedure which permits the quantitative recovery of sunset yellow dye from food samples. The synthesis of the polymer is easy and the method has a good accuracy, sensitivity and repeatability. The polymer has been used in all the experiments performed for the study. It has a unique stability and reusability. This method is convenient for the determination of sunset yellow dye.

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