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The Effect of Temperature on the Migration of Phthalate Plasticizers from Plastic Sachet into Water

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ABSTRACT

Phthalates are compounds used principally as plasticizers, to impact flexibility, workability and durability to polymers used to contain consumer products such as water etc. These phthalates are not chemically bound to polymers; hence they are easily released and migrate into the containing consumer product. The leaching may take place in harsh conditions such as under the sun among others. Hence the "PA" sachet water was used as a case study. PA sachet water was subjected to different room temperatures; 25 ^{o}C, 45 ^{o}C, and 65 ^{o}C for 8 hours each day for 5 days. Liquid-liquid extraction of the phthalates from the different samples of water was carried out using dichloromethane. These samples were analyzed for benzyl butyl phthalate (BBP), di-butyl phthalate (DBP), di-2-ethylbutyl phthalate (DEHP), di (n-octyl) phthalates, DNOP, diisononyl phthalates (DINP using UV-VIS spectroscopy and GC-MS. The results showed that there was no leaching of phthalates into the water when the water was subjected to room temperature up to 65^{o}C.

Keywords: Liquid-Liquid Extraction; Water; BBP, DEHP, DINP

I. INTRODUCTION

Phthalates are used as plasticizers in PVC plastics. As the phthalate plasticizers are not chemically bound to PVC, they can leach, migrate or evaporate into indoor air and atmosphere, foodstuff, other materials, etc. (Heudorf et al., 2007). Despite the improved qualities conferred by the addition of plasticizers, plastic materials exposed to sun, rain, snow, etc undergo degradation and plasticizers (primarily phthalates) are released from the plastic (Přemysl et al., 2005). There are multiple human exposure routes for phthalates including oral, inhalation, ingestion, dermal, and intravenous—through transfusions and other medical devices and procedures (Schettler et al., 2006). Some phthalates are reproductive, respiratory and developmental toxicants in animals and suspected endocrine disruptors in humans (Lyche et al., 2009; Jasna et al., 2007; Bornehag, et al., 2004; Hoppin et al., 2004; Rishikesh et al., 2013; Fromme et al., 2012; Kwak et al., 2009; Crinnion et al., 2010; Lorz et al., 2006; Wormuth et al., 2006; Jaakkola and Knight, 2008).

The aim of the present study was to assess influence of temperature on the rate of phthalate (benzyl butyl phthalate (BBP), di-butyl phthalate (DBP), di-2-ethylbutyl phthalate (DEHP), di (n-octyl) phthalates, DNOP, diisononyl phthalates (DINP) migration from plastic sachet containers into the water. The analytees of interest are shown in Figure 1.

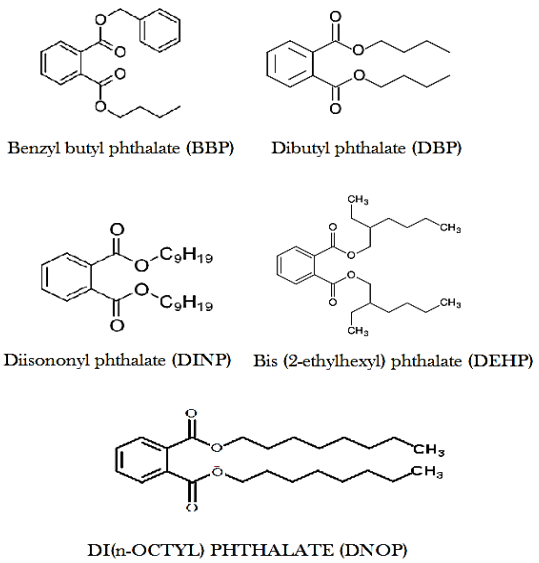

Figure 1. Structures of analyses

II. METHODS AND MATERIAL

2.1 Reagents and Materials

Phthalates were supplied from Supelco (UK). Dichloromethane was supplied from Labscan and anhydrous sodium sulfate was purchased from Merck. The instruments used were gas chromatograph (Shimadzu GC-2010) coupled with a mass spectrometer (Shimadzu QP 2010) and an autosampler (AOC 20i, Shimadzu Corporation), and Spectra UV-VIS Autoscanning spectrophotometer, UV-2602 (Labomed Inc.)

2.2 Sample Preparation

Commercial sachet water with a brand name "PA" was purchased from local markets (Bayelsa State, Nigeria) and used as the case study. The sachet water was divided into three groups and the groups were respectively subjected to room temperatures of 25 ^{o}C, 45 ^{o}C, and 65 ^{o}C. In order to maintain these temperatures, samples were kept in a room with appropriate number of electric bulbs in each case. Samples were left in the room for 8 hours (10 am – 6 pm) for 5 days. Analytes (phthalates) were extracted from the aqueous phases into the organic phases (dichloromethane) by using a separatory funnel. In order to increase the efficiency of extraction, 20 mL of water was extracted with 60 mL (20 mL x 3) of dichloromethane. The organic phase was then pre-concentrated by using a stream of nitrogen gas to a volume of 5 mL. Standard dichloromethane and the three samples were ready for UV scan and GC-MS analysis.

2.3 Analytical Determination

The pre-concentrated samples were scanned with UV Spectrophotometer. GC-MS determination of benzyl butyl phthalate (BBP), di-butyl phthalate (DBP), di-2-ethylbutyl phthalate (DEHP), di (n-octyl) phthalates, DNOP, diisononyl phthalates (DINP) was performed. Separation of target compounds was effected on a TraceGold TG–5MS 5% diphenyl–95% dimethyl polysiloxane capillary column (30m length, 0.25mm i.d., 0.25mm film thickness) from Thermo Scientific. Instrumental conditions include the following oven program: the column temperature was initially set at 80 ^{o}C for 2 min, and then increased at a rate of 17 ^{o}C/min up to 320 ^{o}C. The column temperature was maintained at 320 ^{o}C for 5 min. The mobile phase (high purity helium gas) flow was maintained at a constant rate of 1.2 mL/min. The ion source and transfer line temperature was set at 280 ^{o}C and at 320 ^{o}C respectively. The injector temperature was maintained at 150 ^{o}C. Mass spectra were obtained using electron impact ionization at 70 eV. The identification of target compounds was based on the relative retention time.

III. RESULTLS AND DISCUSSION

The UV scan results are shown in Figure 2. The figure has four spectra; A, B, C, and D. They respectively show the scan results of the blank (dichloromethane), water samples at 25 ^{o}C, 45 ^{o}C, and 65 ^{o}C. All the plots show nothing but the typical spectra of dichloromethane (blank). The results of the GC-MS analyses are shown in Figure 3; spectrum AS is the result of the analysis of the standard mixture of phthalates. Spectra A, B, and C represent results of samples subjected to room temperatures of 25 ^{o}C, 45 ^{o}C, and 65 ^{o}C. The UV and GC-MS analysis show that no leaching took place when the water was subjected to the referenced room temperatures.

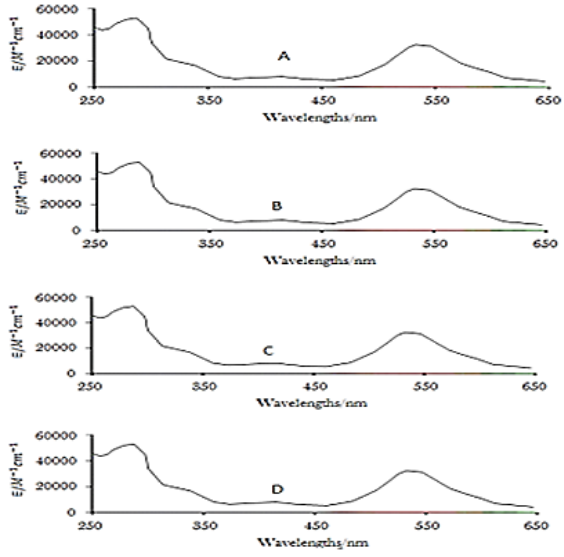

Figure 2. UV-VIS spectra: A = dichloromethane (extracting solvent); B = sample subjected to 25^{o}C room temperature; C = sample subjected to 45 ^{o}C room temperature; D = sample subjected to 65^{o}C room temperature

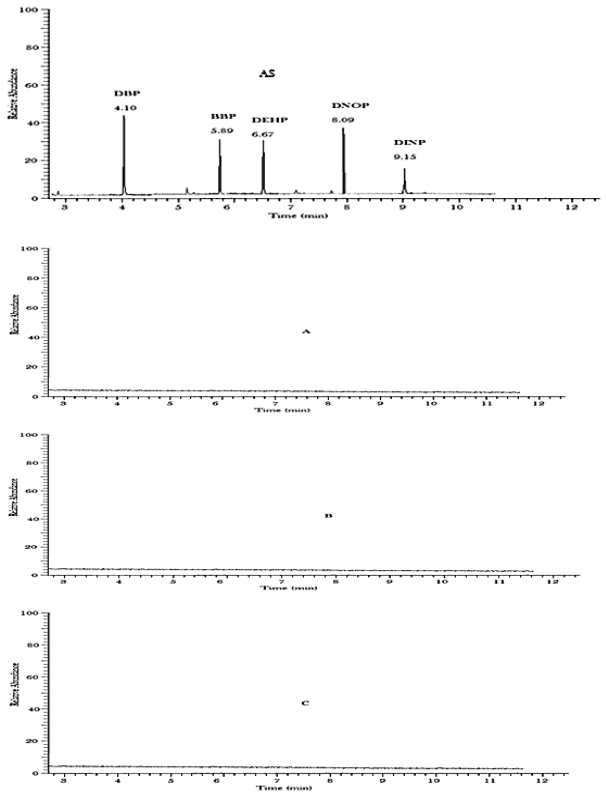

Figure 3. GC-MS spectra: AS = mixture of phthalates; A = sample subjected to 25°C room temperature; B = sample subjected to 45 °C; C = sample subjected to 65°C.

IV.CONCLUSION

Considering the ever growing use of plastic sachets for commercial water and the poor storage conditions, especially, under the sun, there is a possibility of these phthalates leaching into the water when they are heated up in the sun. PA sachet water was subjected to room temperatures of 25°C 45°C, 65°C and their UV and GC-MS spectra show that no leaching of phthalates take place even up to 65°C of room temperature; suggesting that storing sachet water under the sun poses no health risk in respect of phthalates plasticizers.

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