

# EFFECT OF UV-C IRRADIATION ON FORMATION OF POLYCYCLIC AROMATIC HYDROCARBONS IN MODEL SYSTEM

R. Phuathpong and K. Vangnai

Department of Food Science and Technology, Faculty of Agro-Industry, Kasetsart University, Bangkok, 10900, Thailand

\*Corresponding author email: g5615000783@ku.ac.th

**Abstract** – In this study, the effect of ultraviolet light (UV-C) on polycyclic aromatic hydrocarbons (PAHs) contents in liquid model system (distilled water) was studied. The liquid model was exposed to UV radiation (885 mW/m<sup>2</sup>) for 0, 1, 5, 10 and 30 min. A High Performance Liquid Chromatography with diode array detector (HPLC-DAD) was used for PAHs analysis. Reduction of PAHs with UV-C was achieved, total PAHs contents in distilled water was found in the range 62-95% reduction for UV-C exposure time at 30 min. Anthracene (95% reduction) and benzo[a]pyrene (85% reduction) were found highest sensitive to UV-C irradiation. The results obtained from this study will be an important tool in order to reduce carcinogenic PAHs in meat products.

**Key Words** – Polycyclic aromatic hydrocarbons, UV-C, Food model systems

## I. INTRODUCTION

Polycyclic aromatic hydrocarbons (PAHs) commonly refers to a large class of organic compounds that contain carbon and hydrogen and consist of two or more fused aromatic rings, produced through incomplete combustion or pyrolysis of organic matter and geological processes. PAHs can be classified according to the number of condensed aromatic rings. The compounds containing less than five rings are light PAHs such as naphthalene, phenanthrene and acenaphthylene and five or more aromatic rings are heavy PAHs such as benzo[k]fluoranthene, dibenzo[a,h]anthracene and benzo[a]pyrene. The heavy PAHs are more stable and toxic than the other group [1]. In meat products, the PAHs are formed during processing and food preparation at high temperature such as smoking, drying, roasting or grilling. When food is direct contact with a flame, pyrolysis of fats in the meat generates

PAHs. Alternatively, the melted fat from food dripping onto the heat source generates PAHs and will then in turn be deposited on the meat surface [4]. Several PAHs, especially benzo[a]pyrene (BaP), have been classified by the International Agency for Research on Cancer (IARC) as being carcinogenic and mutagenic in humans [2].

The UV-C irradiation (200-400 nm wavelength ranges) commonly used in food industry to clean the food contact surface as well as to sanitize the water. Previous study reported that UV irradiation could reduce 30% of BaP in water [3]. It has been believed that PAHs are converted to alcohols, ketones and ethers by oxidation of peripheral carbon atoms after exposed to the UV irradiation [6]. The aims of this study were to investigate UV-C to decrease the level of PAHs in model system. The result from this study will be an important information to further apply UV-C for PAHs reduction in meat products.

## II. MATERIALS AND METHODS

### *Material*

PAHs standards dissolved in acetonitrile were purchased from Supelco. Concentration of each PAH is shown in Table 1. The chemical structures of these PAHs are shown in Figure 1. Acetonitrile (HPLC grade) and dichloromethane (AR grade) were purchased from RCI Labscan.

### *Model system preparation and UV-C treatment*

A liquid model system was prepared according to method of Ilze *et al.* (2007) with slight modification [3]. 20 mL of liquid models spiked with 20 µL of PAHs standard diluted 1:7 in acetonitrile and pour into plastic Petri dish. The liquid model was exposed to five UV intensity

(885 mW/m<sup>2</sup>, 254 nm) with difference times (0, 1, 5, 10 and 30 min.

Figure 1 Chemical structure of PAHs

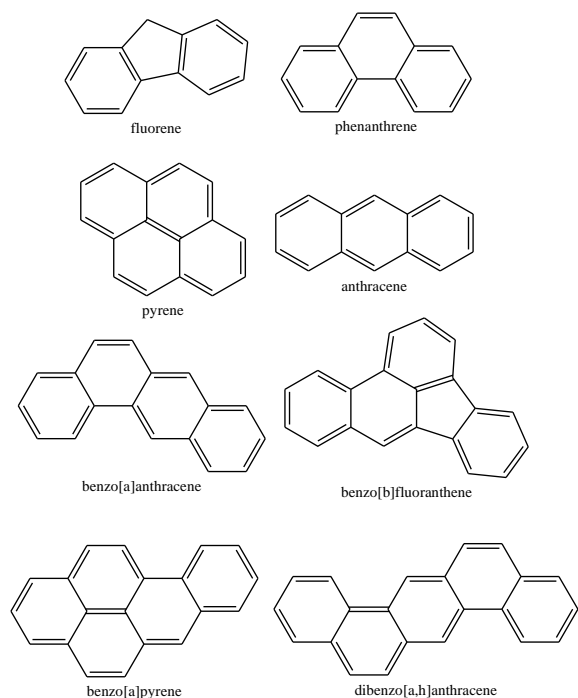


Table 1 PAHs standard concentration

PAHs	Abbreviation	Concentration (ug/mL)
Fluorene	Flu	200
Phenanthrene	Phe	100
Anthracene	Ant	100
Pyrene	Pyr	200
Benzo[a]anthracene	BaA	100
Benzo[b]fluoranthene	BbF	100
Benzo[a]pyrene	BaP	100
Dibenzo[a,h]anthracene	DhA	200

#### PAHs extraction

The 20 mL of liquid model containing PAHs were extracted with 20 mL of dichloromethane in two separating funnels. Dichloromethane layers were collected and evaporated to dryness, and the residue was added with 150  $\mu$ L of dichloromethane and passed through 0.45 $\mu$ m filter before to HPLC analysis.

#### Analysis of PAHs

The PAHs contents were detected by HPLC-DAD at 254 nm. Operating conditions were as follows: ZORBAX Eclipse Plus C18 (250 mm  $\times$  4.6 mm  $\times$  5  $\mu$ m). Analytical chromatography was performed with a flow rate of 1.5 mL/min at 25°C. The injection volume was 20  $\mu$ L. Using a gradient elution program with a mixture of acetonitrile and water which started at 60% of acetonitrile, reaching 100% in 30 min and held 100% during 15 min.

#### Statistical analysis

The experimental design used Completely Randomized Design (CRD). An analysis of variance used to evaluate the data. Significant differences among the means were determined by the one-way ANOVA and Duncan's multiple test ( $p = 0.05$ ) by using a computer based program of SPSS.

### III. RESULTS AND DISCUSSION

Our result indicated that PAHs reduction in water model system with UV-C irradiation was achieved (Table 2). Significant of PAHs decreased was found at 30 min, and the amounts of percent of PAHs reduction at 30 min in distilled water was in the range 62-95%. Comparing between heavy and light PAHs reduction, heavy PAHs, (BaA, BbF, BaP and DhA) tended to reduce a bit faster than light PAHs (Flu, Phe, Ant and Pyr) during the exposure to the UV-C at 1-10 min, however the reduction of heavy and light PAHs were not much difference at 30 min exposure to the UV-C. These results obtained from this study were agreed with Jason and Shaun (2005) who reported that heavy PAHs lean to degrade by UV irradiation faster than light PAHs [5].

Among the eight PAHs, anthracene and benzo[a]pyrene were found to be the most sensitive to UV-C irradiation (95 and 85% reduction, respectively) as they were reported to strongly absorb UV-C at 254 nm than other PAHs in water [8].

Table 2 Effect of UV-C irradiation on PAHs contents in model system (ppb)

PAHs	Exposure time (min) and reduction (%)				
	0	1	5	10	30
Flu	11.90±1.07 <sup>a</sup>	5.51±0.00 <sup>b</sup> (54)	4.90±0.00 <sup>b</sup> (59)	4.79±0.00 <sup>b</sup> (60)	4.54±0.00 <sup>b</sup> (62)
Phe	2.71±0.03 <sup>a</sup>	1.30±0.04 <sup>bc</sup> (52)	1.42±0.38 <sup>b</sup> (48)	1.33±0.10 <sup>b</sup> (51)	0.68±0.37 <sup>c</sup> (75)
Ant	3.25±0.24 <sup>a</sup>	1.30±0.16 <sup>b</sup> (60)	1.07±0.33 <sup>bc</sup> (67)	0.66±0.09 <sup>cd</sup> (80)	0.15±0.06 <sup>d</sup> (95)
Pyr	3.65±0.11 <sup>a</sup>	2.33±0.20 <sup>bc</sup> (36)	2.45±0.17 <sup>bc</sup> (33)	2.27±1.13 <sup>b</sup> (38)	1.05±0.00 <sup>d</sup> (71)
BaA	4.93±0.66 <sup>a</sup>	3.82±1.13 <sup>ab</sup> (23)	3.10±0.74 <sup>ab</sup> (37)	3.31±1.08 <sup>ab</sup> (33)	1.42±1.35 <sup>c</sup> (71)
BbF	9.77±1.06 <sup>a</sup>	6.23±0.00 <sup>ab</sup> (36)	5.80±1.21 <sup>ab</sup> (41)	4.40±2.53 <sup>ab</sup> (55)	2.82±1.98 <sup>c</sup> (71)
BaP	4.48±0.77 <sup>a</sup>	2.19±1.79 <sup>ab</sup> (51)	2.28±0.63 <sup>b</sup> (49)	2.57±0.56 <sup>b</sup> (43)	0.67±0.01 <sup>c</sup> (85)
DhA	1.26±0.26 <sup>a</sup>	0.68±0.14 <sup>b</sup> (46)	0.34±0.03 <sup>b</sup> (73)	0.32±0.23 <sup>b</sup> (75)	0.30±0.14 <sup>b</sup> (76)
Σlight PAHs	21.51	10.44 (51)	9.84 (54)	9.05 (58)	6.42 (70)
Σheavy PAHs	20.44	12.92 (37)	11.52 (44)	10.6 (48)	5.21 (75)
Total PAHs	41.95	23.36 (44)	21.36 (49)	19.65 (53)	11.63 (72)

<sup>a-d</sup> Mean values with different subscripts in each row indicate a significant difference ( $p < 0.05$ ).

no subscripts is no significant difference ( $p \geq 0.05$ ).

SD = Standard deviation

Σlight PAHs = fluorene, phenanthrene, anthracene and pyrene

Σheavy PAHs = benzo[a]anthracene, benzo[b]fluoranthene, benzo[a]pyrene and dibenzo[a,h]anthracene

#### IV. CONCLUSION

The results showed the ability of UV-C to PAHs reduction in liquid model system. PAHs decreased at 30 min UV-C exposure time were found to be greater than other exposure times. Heavy PAHs reduced a bit faster than light PAHs within 10 min. This study will provide useful information to further apply UV-C treatment to reduce carcinogenic PAHs in meat products.

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