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Bisphenol A and the related alkylphenol contaminants in crustaceans and their potential bioeffects

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Abstract. Bisphenol A is widely used in plastic and other industrial consumer products. Release of bisphenol A and its analogues into the aquatic environment during manufacture, use and disposal has been a great scientific and public concern due to their toxicity and endocrine disrupting effects on aquatic wildlife and even human beings. More recent studies have shown that these alkylphenols may affect the molting processes and survival of crustacean species such as American lobster, crab and shrimp. In this study, we have developed gas chromatography with flame ionization detection (GC-FID) and gas chromatography-mass spectrometric (GC-MS) methods for the determination of bisphenol A and its analogues in shrimp *Macrobrachium rosenbergii*, blue crab *Callinectes sapidus* and American lobster *Homarus americanus* samples. Bisphenol A, 2,4-bis-(dimethylbenzyl)phenol and 4-cumylphenol were found in shrimp in the concentration ranges of 0.67–5.51, 0.36–1.61, and < LOD (the limit of detection)-1.96 ng/g (wet weight), and in crab of 0.10-0.44, 0.13-0.62, and 0.26-0.58 ng/g (wet weight), respectively. In lobster tissue samples, bisphenol A, 2-t-butyl-4-(dimethylbenzyl)phenol, 2,6-bis-(t-butyl)-4-(dimethylbenzyl)phenol, 2,4-bis-(dimethybenzyl)phenol, 2,4-bis-(dimethylbenzyl)-6-t-butylphenol and 4-cumylphenol were determined at the concentration ranges of 4.48-7.01, 1.23-2.63, 2.71-9.10, 0.35-0.91, 0.64-3.25, and 0.44-1.00 ng/g (wet weight), respectively. At these concentration levels, BPA and its analogs may interfere the reproduction and development of crustaceans, such as larval survival, molting, metamorphosis and shell hardening.

Keywords: bisphenol A; alkylphenol; 4-cumylphenol; 2,4-bis-(dimethylbenzyl)phenol; 2-t-butyl-4-(dimethylbenzyl)phenol; gas chromatography-mass spectrometry; GC-FID; lobster, crab, shrimp

1. Introduction

Bisphenol A (BPA, 4,4'-isopropylidine diphenol) is a commercially important chemical with an estimated worldwide annual production of 5 million tons in 2010. Over 95% of all BPA produced is used as a monomer in the production of polycarbonate plastic and epoxy resins, which

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Okuda, K., Takiguchi, M. and Yoshihara, S. (2010), "In vivo estrogenic potential of 4-methyl-2,4-bis (4-hydroxyphenyl)pent-1-ene, an active metabolite of bisphenol A, in uterus of ovariectomized rat", *Toxicol Lett*., **197**(1), 7-11.

Segner, H., Caroll, K., Fenske, M., Janssen, C.R., Maack, G., Pascoe, D., Schäfers, C., Vandenbergh, V.F., Watts, M. and Wenzel, A. (2003), "Identification of endocrine-disrupting effects in aquatic vertebrates and invertebrates: report from the European IDEA project", *Ecotoxicol Environ. Safety*, **54**(3), 302-314.

Shao, B., Han, H., Li, D., Zhao, R., Meng, J. and Ma, Y. (2005) "Analysis of nonylhenol, octylphenol and bisphenol A in animal tissues by liquid chromatography-tandem mass spectrometry with accelerated solvent extraction", *Se Pu – Chinese Journal of Chromatography/Zhongguo Hua Xue Hui*, **23**(4), 362-365.

Shi, T. (2012), "Determination of trace amounts of bisphenol A, cocaine, and benzoylecgonine on bank notes and receipts", Thesis; University of Massachusetts Dartmouth, North Dartmouth, MA, USA.

Stuart, J.D., Capulong, C.P., Launer, K.D. and Pan, X. (2005), "Analyses of phenolic endocrine disrupting chemicals in marine samples by both gas and liquid chromatography-mass spectrometry", *J. Chromatogr. A*, **1079**(1-2), 136-145.

Terasaki, M., Shiraishi, F., Nishikawa, T., Edmonds, J.S., Morita, M. and Makino, M. (2005), "Estrogenic activity of impurities in industrial grade bisphenol A", *Environ. Sci. Technol*., **39**(10), 3703-3707.

U.S. EPA (2009), Screening-Level Hazard Characterization, Alkylphenols Category; Hazard Characterization Document, Washington, D.C., USA, September.

Wang, B., Huang, B., Jin, W., Zhao, S., Li, F., Hu, P. and Pan, X. (2013), "Occurrence, distribution, and sources of six phenolic endocrine disrupting chemicals in the 22 river estuaries around Dianchi Lake in China", *Environ. Sci. Pollut. Res*., **20**(5), 3185-3194.

Watkins, D.J., Tellez-Rojo, M.M., Ferguson, K.K., Lee, J.M., Solano-Gonzalez, M., Blank-Goldenberg, C., Peterson, K.E. and Meeker, J.D. (2014), "*In utero* and peripubertal exposure to phthalates and BPA in relation to female sexual maturation", *Environ. Res*., **134**, 233-241.

WHO (2011), Toxicological and Health Aspects of Bisphenol A, *Report of Joint FAO/WHO Expert Meeting* (2-5 November, 2010) and *Report of Stakeholder Meeting on Bisphenol A* (1 November, 2010), Ottawa, Canada.

WSP (2007), Screening of Bisphenol A in Fish from Swedish Waters.

Yoshida, T., Horie, M., Hoshino, Y. and Nakazawa, H. (2001), "Determination of bisphenol A in canned vegetables and fruit by high performance liquid chromatography", *Food Addit. Contam*., **18**(1), 69-75.

Yoshihara, S., Mizutare, T., Makishima, M., Suzuki, N., Fujimoto, N., Igaragshi, K. and Ohta, S. (2004), "Potent estrogenic metabolites of bisphenol A and bisphenol B formed by rat liver S9 fraction: their structures and estrogenic potency", *Toxicol Sci*., **78**(1), 50-59.

Zhu, Z. and Zuo, Y. (2013), "Bisphenol A and other alkylphenols in the environment – occurrence, fate, healt effects and analytical techniques", *Adv. Environ. Res*., *Int. J*., **2**(3), 179-202.

Zuo, Y. (2014), *High-Performance Liquid Chromatography* (*HPLC*)*: Principles*, *Procedures and Practices*, Nova Science Publishers Inc., New York, NY, USA.

Zuo, Y. and Zhu, Z. (2014), "Simultaneous identification and quantification of 4-cumylphenol, 2,4-bis-(dimethylbenzyl) phenol and bisphenol A in prawn Macrobrachium rosenbergii", *Chemosphere*, **107**, 447-453.

Zuo, Y., Zhang, K. and Lin, Y. (2007), "Microwave-accelerated derivatization for the simultaneous gas chromatography-mass spectrometric analysis of natural and synthetic estrogenic steroid hormones", *J. Chromatography A*, **1148**(2), 211-218.

Zuo, Y., Zhang, K. and Zhou, S. (2013), "Determination of estrogenic steroids and microbial and photochemical degradation of 17α-ethinylestradiol (EE2) in lake surface water, A case study", *Environ. Sci.: Process. Impact*., **15**, 1529-1535.

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