JEP> Vol.3 No.11, November 2012

OPEN ACCESS

UV Light Induced Transformation of 1-Methylnaphthalene in the Presence of Air and Its Implications for Contaminants Research

PDF (Size:546KB) PP. 1519-1531 DOI: 10.4236/jep.2012.311168

Author(s)

Yong-Lai Feng, Jyoti P. Nandy, Yuqing Hou, Francois Breton, Ben Lau, Jianshun Zhang, Jiping Zhu

ABSTRACT

Understanding chemical transformations of contaminants and the resulting products is extremely important in devising proper monitoring methods for such contaminants and in assessing potential human exposure to the transformation products in the environment. Ultraviolet (UV) light from the sun can induce various photochemical transformations of contaminants in the environment. Alkylnaphthalenes are light-molecular-weight polycyclic aromatic hydrocarbons (PAHs) which are one of the most widespread organic pollutants present in ambient air as a result of a variety of incomplete combustion sources. In this study, 1-methylnapthalene,a typical example of an alkylnaphthalene, was subjected to UV irradiation to investigate its transformation in the presence and absence of air. Twenty-one products were detected in the reaction mixtures. Some photo-oxidation products were identified, including both ring-opened and ring-retained oxygenated compounds, such as 1-naphthaldehyde, 1-naphthoic acid, 1-naphthalenemethanol and phthalic anhydride. Although dimeric products were observed in the presence of air, more were found in the presence of helium or argon gas, indicating a different photo-oxidation pathway from those commonly observed in other media, such as water. Under just 48 hours of exposure to the UV light in the presence of air, three major products were formed with a production yield of about 10% each. Compared to 1-methylnapthalene, the UV induced transformation products observed in this study are more volatile, acidic, water soluble or toxic. The formation of these products may significantly change our understanding of the risks assessed solely from the parent compound in contaminants research and supports the inclusion of airborne transformations of the parent compound in risk assessment.

KEYWORDS

Transformation Products; 1-Methylnaphthalene; UV Light; Photo-Oxidation; Contaminants Research

Cite this paper

Y. Feng, J. Nandy, Y. Hou, F. Breton, B. Lau, J. Zhang and J. Zhu, "UV Light Induced Transformation of 1-Methylnaphthalene in the Presence of Air and Its Implications for Contaminants Research," *Journal of Environmental Protection*, Vol. 3 No. 11, 2012, pp. 1519-1531. doi: 10.4236/jep.2012.311168.

References

[1] P. T. Williams, K. D. Bartle and G. E. Andrews, "The Relation between Polycyclic Aromatic Compounds in Diesel Fuels and Exhaust Particulates," Fuel, Vol. 65, No. 8, 1986, pp. 1150-1158. doi:10.1016/0016-2361(86)90184-5

[2] P. F. Nelson, "Combustion-Generated Polycyclic Aromatic Hydrocarbons in Diesel Exhaust Emissions," Fuel, Vol. 68, No. 3, 1989, pp. 283-286. doi:10.1016/0016-2361(89)90088-4

[3] B. Zielinska, J. C. Sagebiel, G. Harshfield, A. W. Gertler and W. R. Pierson, "Volatile Organic Compounds up to C_{20} Emitted from Motor Vehicles; Measurement Methods," Atmospheric Environment, Vol. 30, No. 12, 1996. pp. 2269-2286. doi:10.1016/1352-2310(95)00116-6

[4] L. C. Marr, T. W. Kirchstetter, R. A. Harley, A. H. Miguel, S. V. Heringand and S. K. Hammond, "Characterization of Polycyclic Aromatic Hydrocarbons in Motor Vehicle Fuels and Exhaust Emissions," Environmental Science & Technology, Vol. 33, No. 18, 1999, pp. 3091 3099. doi:10.1021/es981227l

- Open Special Issues
- Published Special Issues
- Special Issues Guideline

JEP Subscription

Most popular papers in JEP

About JEP News

Frequently Asked Questions

Recommend to Peers

Recommend to Library

Contact Us

[5] P. J. Tancell, M. M. Rhead, R. D. Pemberton and J. Braven, "Survival of Polycyclic Aromatic Hydrocarbons during Diesel Combustion," Environmental Science & Technology, Vol. 29, No. 11, 1995, pp. 2871-2876. doi:10.1021/es00011a025

[6] T. J. Truex, J. M. Norbeck, M. R. Smith, J. Arey, N. Kado and B. Okamoto, "Evaluation of Factors That Affect Diesel Exhaust Toxicity," Contract No. 94-312, Final Report to California Air Resources Board, Sacramento, 1998, 287 p.

[7] F. Reisen and J. Arey, "Atmospheric Reactions Influence Seasonal PAH and Nitro-PAH Concentrations in the Los Angeles Basin," Environmental Science & Technology, Vol. 39, No. 1, 2005, pp. 64-73. doi:10.1021/es035454l

[8] J. J. Schauer, M. J. Kleeman, G. R. Cass and B. R. T. Simoneit, "Measurement of Emissions from Air Pollution Sources. 2. C-1 through C-30 Organic Compounds from Medium Duty Diesel Trucks," Environmental Science & Technology, Vol. 33, No. 10, 1999, pp. 1578-1587. doi:10.1021/es980081n

[9] J. J. Schauer, M. J. Kleeman, G. R. Cass and B. R. T. Simoneit, "Measurement of Emissions from Air Pollution Sources. 3. C-1-C-29 Organic Compounds from Fireplace Combustion of Wood," Environmental Science & Technology, Vol. 35, No. 9, 2001, pp. 1716-1728. doi:10.1021/es001331e

[10] F. Wania and D. Mackay, "Tracking the Distribution of Persistent Organic Pollutants," Environmental Science & Technology, Vol. 30, No. 9, 1996, pp. 390A-396A. doi:10.1021/es962399q

[11] P. T. Phousongphouang and J. Arey, "Rate Constants for the Gas-Phase Reactions of a Series of Alkylnaphthalenes with the OH Radical," Environmental Science & Technology, Vol. 36, No. 9, 2002, pp. 1947-1952. doi:10.1021/es011434c

[12] L. Wang, R. Atkinson and J. Arey, "Dicarbonyl Products of the OH Radical-Initiated Reactions of Naphthalene and the C1 and C2-Alkylnaphthalenes," Environmental Science & Technology, Vol. 41, No. 8, 2007, pp. 2803-2810. doi:10.1021/es0628102

[13] N. Nishino, J. Arey and R. Atkinson, "Yields of Glyoxal and Ring-Cleavage Co-Products from the OH Radical Initiated Reactions of Naphthalene and Selected Alkylnaphthalenes," Environmental Science & Technology, Vol. 43, No. 22, 2009, pp. 8554-8560. doi:10.1021/es902018v

[14] M. G. Ehrhardt, M. C.Bicego and R. R. Weber, "Photo Oxidation of 1-Methylnaphthalene Dissolved in Seawater and Exposed to Sunlight under Quasi-Environmental Conditions," Journal of Photochemistry and Photobiology A, Vol. 108, No. 2-3, 1997, pp. 253-259. doi:10.1016/S1010-6030(97)00079-8

[15] R. Atkinson, "Atmospheric Chemistry of VOCs and NO_x," Atmospheric Environment, Vol. 34, No. 12-14, 2000, pp. 2063-2101. doi:10.1016/S1352-2310(99)00460-4

[16] F. Reisen, S. Wheeler and J. Arey, "Methyl and Dimethyl-/Ethyl-Nitronaphthalenes Measured in Ambient Air in Southern California," Atmospheric Environment, Vol. 37, No. 26, 2003, pp. 3653-3657. doi:10.1016/S1352-2310(03)00469-2

[17] A. W. H. Chan, K. E. Kautzman, P. S. Chhabra, J. D. Surratt, M. N. Chan, J. D. Crounse, A. Kurten, P. O. Wennberg, R. C. Flagan and J. H. Seinfeld, "Secondary Organic Aerosol Formation from Photooxidation of Naphthalene and Alkylnaphthalenes: Implications for Oxidation of Intermediate Volatility Organic Compounds ($IVOC_s$)," Atmospheric Chemistry and Physics, Vol. 9, 2009, pp. 3049-3060. doi:10.5194/acp-9-3049-2009

[18] C. Tixier, M. Sancelme, E. Bonnemoy, A. Cuer and H. Veschambre, "Degradation Products of a Phenylurea Herbicide, Diuron: Synthesis, Ecotoxicity, and Biotransformation," Environmental Toxicology and Chemistry, Vol. 20, No. 7, 2001, pp. 1381-1389. doi:10.1002/etc.5620200701

[19] A. B. A. Boxall, C. J. Sinclair, K. Fenner, D. Kolpin and S. J. Maud, "When Synthetic Chemicals Degrade in the Environment," Environmental Science & Technology, Vol. 38, No. 19, 2004, pp. 368A-375A. doi:10.1021/es040624v

[20] A. B. A. Boxall, "Transformation Products of Synthetic Chemicals in the Environment," Berlin/Heidelberg, Springer, 2009.

[21] M. Pakarinen, M. Koivuluhta, N. Kalkkinen, H. Keskinen, H. Nordman, T. Estlander, O. Tupasela, R. Jolanki, A. I. Lauerma, P. Pf?ffli and H. Alenius, "Phthalic Anhydride Allergy: Development and Characterization of Optimized Hapten-Carrier Conjugates for Improved Diagnosis," Allergy, Vol. 57, No. 10, 2002, pp. 894-899. doi:10.1034/j.1398-9995.2002.23579.x

[22] M. Wernfors, J. Nielsen, A. Schütz and S. Skerfving, "Phthalic Anhydride-Induced Occupational Asthma," International Archives of Allergy and Applied Immunology, Vol. 79, No. 1, 1986, pp. 77-82. doi:10.1159/000233946

[23] C. E. Cerniglia, J. P. Freeman, J. R. Althaus and C. van Baalen, "Metabolism and Toxicity of 1-