

# 桌上型電腦塑膠物質熱裂解資源回收之研究

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## 摘要

本研究主要以探討桌上型廢電腦監視器之塑膠物質熱裂解為主。廢電腦外殼成分主要為丙烯腈(acrylonitrile)、丁二烯(butadiene)及苯乙烯(styrene)三成分之共聚合物(ABS)，經由元素分析結果顯示，碳、氫與氮所佔的重量百分比分別為84.32、7.71與7.57%。動力分析方面，利用不同的升溫速率(分別為2、5及10 /min)，探討廢電腦塑膠物質在氮氣中熱裂解之情形，由質量消失曲線計算，以求得活化能E、頻率因子A及反應級數n。由實驗數據求得動力參數值分別為E = 40.3 kcal/mol, A = 5.31 × 10<sup>11</sup> 1/min, n = 1, ABS樹脂在氮氣中熱裂解可以一個總反應方程式表示： $dX/dt = A \cdot \exp(-E/RT)(1-X)$  其中 X：轉化率 t：時間 R：氣體常數(1.987 × 10<sup>-3</sup> kcal/mol-K) T：絕對溫度(K) 產物分析方面，廢電腦塑膠物質在氮氣中400 裂解產物百分比分別為氣體約14%，粗裂解油約75%及固體殘餘物約11%。氣體主要產物為丙烷與少量之toluene、ethyl benzene與styrene等有機化合物。粗裂解油為一深咖啡色帶有刺鼻味之黏稠狀油類液體。經由分餾後之產物主要為甲苯、乙苯與苯乙烯，約佔油品總量的60-70%。固體殘餘物主要成分為碳元素，約佔83%。

關鍵詞：熱裂解；丙烯腈；-丁二烯-苯乙烯(ABS) 樹脂；活化能；頻率因子；反應級數

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## 參考文獻

1. www.epa.gov.tw 2. www.niea.gov.tw 3. Ali, K., Simsek, E. H., Burhanettin, C. and Ali, Y., " Thermal degradation of polystyrene wastes in various solvents, " *Journal of Analytical and Applied Pyrolysis*, Vol. 62, PP.273-280, (2002).
4. Cornelia, V., Pakdel, H., Mihai, B., Onu, P., Darie, H. and Ciocalteu, S., " Thermal and catalytic decomposition of mixed plastics, " *Journal of Analytical and Applied Pyrolysis*, Vol. 57, PP.287-303, (2001).
5. Chen, F. Z. and Qian, J. L., " Studies on the thermal degradation of polybutadiene, " *Fuel Processing Technology*, Vol. 67, PP.53-60, (2000).
6. Day, M., Cooney, J. D. and Touchette, B. C., " Pyrolysis of mixed plastics used in the electronics industry, " *Journal of Analytical and Applied Pyrolysis*, Vol. 52, PP.199-224, (1999).
7. Dong, D., Tasaka, S., Aikawa, S., Kamiya, S., Inagaki, N. and Inoue, Y., " The thermal degradation of acrylonitrile-butadiene-styrene terpolymer in bean oil, " *Polymer Degradation and Stability*, Vol. 73, PP.319-326, (2001).
8. Gersten, J., Fainberg, V., Garbar A., Hetsroni, G. and Shindler Y., " Utilization of waste polymers through one-stage low temperature pyrolysis with oil shale, " *Fuel*, Vol. 78, PP.987-990, (1999).
9. Howell, B. A., Cui, Y. and Priddy, D. B., " Assessment of the thermal degradation characteristics of isomeric poly(styrene) using TG, TG/MS and TG/GC/MS, " *Thermochimica acta*, Vol. 396, PP.167-177, (2003).
10. Kaminsky, W. and Kim, J. S., " Pyrolysis of mixed plastics into aromatic, " *Journal of Analytical and Applied Pyrolysis*, Vol. 51, PP.127-134, (1999).
11. Katsuhide, M., Hirano, Y., Sakata, Y. and Uddin, M. A., " Basic study on a continuous flow reactor for thermal degradation of polymers, " *Journal of Analytical and Applied Pyrolysis*, Vol. 65, PP.71-90, (2002).
12. Kiran, N., Ekinci, E. and Snape, C. E. " Recycling of plastic wastes via pyrolysis, " *Resources Conservation & Recycling*, Vol. 29, PP.273-283, (2000).
13. Lee, C. H., Chang, S. L., Wang, K. M. and Wen, L. C., " Management of scrap computer recycling in Taiwan, " *Journal of Hazardous Materials*, Vol. 73, PP.209-220, (2000).
14. Lee, S. Y., Yoon, J. H., Kim, J. R. and Park, D.W., " Catalytic degradation of polystyrene over natural clinoptilolite, " *Polymer Degradation and Stability*, Vol. 74, PP.297-305, (2001).
15. Mihai, B., Uddin, M. A., Akinori, M., Yusaku, S. and Cornelia, V., " The role of temperature program and catalytic system on the quality of acrylonitrile—butadiene—styrene oil, " *Journal of Analytical and Applied Pyrolysis*, Vol. 63, PP.43-57, (2002).
16. Nishizaki, H., Yoshida, K. and Wang, J. H., " Comparative study of various methods for thermogravimetric analysis of polystyrene, " *Journal of Applied Polymer Science*, Vol.25, PP.2869-2877(1980).
17. Schnabel, W., Levchik, G. F., Wilkie, C. A., Jiang, D.D., Levchik, S.V., " Thermal degradation of polystyrene poly(1,4-butadiene) and copolymers of styrene and 1,4-butadiene irradiated under air or argon with 60Co-<sup>-</sup>rays " , *Polymer Degradation and Stability*, Vol. 63, PP.365-375, (1999).
18. Shun, D., Bae, D. H., Cho, S. H. and Han, K. H., " Bench scale fluidized bed pyrolysis of waste ABS resin, " *Korea Institute of Energy Research*, PP.305-343. (<http://wire0.ises.org/wire/doclibs/KoreaConf.nsf/0/39a1cfb8d86b6af9c12565a0004e6405?OpenDocument>)
19. Solpan, D. and Guven, O., " The thermal stability of allyl alcohol with acrylonitrile and methyl methacrylate, " *Polymer Degradation and Stability*, Vol. 60, PP.367-370, (1998).
20. Sorum, L., Gronli, M. G. and Hustad, J. E., " Pyrolysis characteristics and kinetics of municipal solid wastes, " *FUEL*, Vol. 80, PP.1217-1227, (2001).
21. Suzuki, M. and Wilkie, C. A., " The thermal degradation of acrylonitrile—butadiene—styrene terpolymer as study by TGA/FTIR, " *Polymer Degradation and Stability*, Vol. 47, PP.217-221, (1995a).
22. Suzuki, M. and Wilkie, C. A., " The thermal degradation of acrylonitrile—butadiene—styrene terpolymer grafted with methacrylic acid, " *Polymer Degradation and Stability*, Vol. 47, PP.223-228, (1995).
23. Thomas, J. X. and Wilkie, C. A., " Thermal degradation of poly(styrene-g-acrylonitrile), " *Polymer Degradation and Stability*, Vol. 56, PP.109-113, (1997).
24. Ukei, H., Hirose, T., Horikawa, S., Takai, Y., Taka, M., Azuma, N. and Ueno, A., " Catalytic degradation of polystyrene into styrene and a design of recyclable polystyrene with dispersed catalysts, " *Catalysis Today*, Vol. 62, PP.67-75, (2000).
25. Yang, M. H., " The thermal degradation of acrylonitrile—butadiene — styrene terpolymer under various gas condition, " *Polymer testing*, Vol.19, PP.105-110, (2000).
26. Zhibo, Z., Nishio, S., Morioka, Y., Ueno A., Ohkita, H., Tochiara, Y., Mizushima, T. and Kakuta, N., " Thermal and chemical recycle of waste polymers, " *Catalysis Today*, Vol. 29, PP.303-308, (1996).
27. 石化工會, " 石化工業 " , 第二十三卷第九期, (2002)。
28. 楊思廉, " 新材料塑膠 " , 高立圖書公司, (1983)。
29. 孫逸民, 陳玉舜, 趙敏勳, 謝明學, 劉興鑑, " 儀器分析 " , (2000)。
30. 劉玉芬, " 氧氣對鋁箔包熱裂解之影響 " , 國立台灣大學環境工程學研究所碩士論文, (1999)。