**Transformation of polyacrylamide during hydrothermal carbonization and pyrolysis**

Gaoxiang Qi1,2,\*

1 Institute of Wetland Agriculture and Ecology, Shandong Academy of Agricultural Sciences, Jinan 250100, China

2 State Key Laboratory of Nutrient Use and Management, Shandong Academy of Agricultural Sciences, Jinan 250100, China

Corresponding address: No. 2 Sangyuan Road, Licheng District, Jinan 250100, China

Email:vip\_qigx@163.com

**Table S1** C species detected in the liquid phase derived from HTC treated PAM

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| No. | Compounds | Formula | MW | Types | Intensity/\*10^5 | | | | | | | | |
| PAM | | 150ºC | | 180ºC | | 210ºC | | 240ºC |
| 1 | trans-3-Hexenoic acid | C6H10O2 | 114.06824 | Acids | 0.00 | 0.00 | | 0.12 | | 0.00 | | 0.00 | |
| 2 | Cyclohexanecarboxylic acid | C7H12O2 | 128.08367 | Acids | 0.00 | 0.00 | | 0.00 | | 0.04 | | 0.24 | |
| 3 | α-Linolenic acid | C18H30O2 | 278.22418 | Acids | 0.00 | 1.27 | | 0.31 | | 0.00 | | 0.00 | |
| 4 | 12-Oxo phytodienoic acid | C18H28O3 | 292.20326 | Acids | 0.00 | 0.07 | | 0.00 | | 0.21 | | 0.15 | |
| 5 | 13(S)-HOTrE | C18H30O3 | 294.219 | Acids | 0.00 | 2.00 | | 0.45 | | 0.21 | | 0.53 | |
| 6 | Eucalyptol | C10H18O | 154.13562 | Alcohols | 0.00 | 1.32 | | 0.00 | | 0.10 | | 0.00 | |
| 7 | PEG n5 | C10H22O6 | 238.14129 | Alcohols | 0.00 | 5.77 | | 9.50 | | 13.66 | | 21.64 | |
| 8 | PEG n6 | C12H26O7 | 282.16748 | Alcohols | 1.04 | 4.73 | | 7.32 | | 10.69 | | 13.69 | |
| 9 | PEG n8 | C16H34O9 | 370.21951 | Alcohols | 0.78 | 2.70 | | 3.90 | | 6.27 | | 7.07 | |
| 10 | Bis(4-ethylbenzylidene)sorbitol | C24H30O6 | 414.2035 | Alcohols | 0.06 | 0.11 | | 0.30 | | 0.50 | | 0.21 | |
| 11 | PEG n10 | C20H42O11 | 458.27205 | Alcohols | 0.00 | 1.18 | | 1.97 | | 2.96 | | 3.45 | |
| 12 | PEG n11 | C22H46O12 | 502.29832 | Alcohols | 0.00 | 0.00 | | 1.40 | | 2.21 | | 2.62 | |
| 13 | PEG n12 | C24H50O13 | 546.32464 | Alcohols | 0.00 | 0.00 | | 0.00 | | 1.86 | | 1.88 | |
| 14 | PEG n13 | C26H54O14 | 590.35079 | Alcohols | 0.00 | 0.00 | | 0.00 | | 1.20 | | 1.33 | |
| 15 | trans,trans-2,4-Heptadienal | C7H10O | 110.07334 | Aldehydes | 0.00 | 0.00 | | 0.00 | | 0.24 | | 0.00 | |
| 16 | 2,4-Dimethylbenzaldehyde | C9H10O | 134.07307 | Aldehydes | 0.00 | 0.10 | | 0.09 | | 0.16 | | 0.14 | |
| 17 | Vanillin | C8H8O3 | 152.04729 | Aldehydes | 0.66 | 0.00 | | 0.00 | | 0.00 | | 0.00 | |
| 18 | Citral | C10H16O | 152.11996 | Aldehydes | 0.00 | 0.00 | | 2.24 | | 4.68 | | 1.41 | |
| 19 | 3,5-di-tert-Butyl-4-hydroxybenzaldehyde | C15H22O2 | 234.16167 | Aldehydes | 0.51 | 0.61 | | 0.65 | | 0.68 | | 0.68 | |
| 20 | Ethyl sorbate | C8H12O2 | 140.08363 | Esters | 0.00 | 0.00 | | 0.21 | | 0.34 | | 0.30 | |
| 21 | Palmitelaidic acid methyl ester | C17H32O2 | 268.23981 | Esters | 0.00 | 0.04 | | 0.08 | | 0.00 | | 0.24 | |
| 22 | Citroflex 4 | C18H32O7 | 360.21411 | Esters | 0.60 | 0.00 | | 0.00 | | 0.00 | | 0.00 | |
| 23 | Bis(2-ethylhexyl) phthalate | C24H38O4 | 390.27634 | Esters | 0.17 | 0.21 | | 0.22 | | 0.29 | | 0.35 | |
| 24 | Citroflex A-4 | C20H34O8 | 402.22468 | Esters | 0.19 | 0.10 | | 0.00 | | 0.00 | | 0.00 | |
| 25 | Poly THF n3 | C12H26O4 | 234.18281 | Ethers | 0.24 | 0.09 | | 0.00 | | 0.18 | | 0.21 | |
| 26 | OPEO | C16H26O2 | 250.19301 | Ethers | 0.00 | 0.00 | | 0.00 | | 0.20 | | 0.00 | |
| 27 | Poly THF n4 | C16H34O5 | 306.24016 | Ethers | 0.26 | 0.11 | | 0.05 | | 0.26 | | 0.32 | |
| 28 | Poly THF n5 | C20H42O6 | 378.29757 | Ethers | 0.17 | 0.08 | | 0.00 | | 0.20 | | 0.24 | |
| 29 | α-Pinene-2-oxide | C10H16O | 152.11993 | Hydrocarbons | 0.00 | 1.36 | | 1.04 | | 0.08 | | 0.64 | |
| 30 | Acetophenone | C8H8O | 120.05767 | Ketones | 0.00 | 0.00 | | 0.00 | | 0.29 | | 0.53 | |
| 31 | Isophorone | C9H14O | 138.10434 | Ketones | 0.00 | 1.04 | | 0.00 | | 0.98 | | 0.70 | |
| 32 | L-(-)-Carvone | C10H14O | 150.10435 | Ketones | 0.00 | 0.00 | | 0.93 | | 0.82 | | 0.00 | |
| 33 | Muscone | C16H30O | 238.22921 | Ketones | 0.00 | 1.46 | | 3.94 | | 3.11 | | 2.91 | |
| 34 | Galaxolidone | C18H24O2 | 272.17707 | Ketones | 0.00 | 0.10 | | 0.00 | | 0.28 | | 0.69 | |
| 35 | 9-Oxo-ODE | C18H30O3 | 294.21911 | Ketones | 2.02 | 1.58 | | 0.00 | | 0.74 | | 0.42 | |

**Table S2** N species detected in the liquid phase derived from HTC treated PAM

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| No. | Compounds | Formula | MW | Types | Intensity/\*10^5 | | | | | | | | |
| PAM | | 150ºC | | 180ºC | | 210ºC | | 240ºC |
| 1 | 2-Aminobutyric acid | C4H9NO2 | 103.06368 | Amides | 0.00 | 0.35 | | 0.16 | | 0.68 | | 0.12 | |
| 2 | Caprolactam | C6H11NO | 113.08427 | Amides | 81.76 | 38.06 | | 31.98 | | 0.14 | | 3.24 | |
| 3 | L-Pyroglutamic acid | C5H7NO3 | 129.04263 | Amides | 0.00 | 0.00 | | 0.00 | | 7.90 | | 6.63 | |
| 4 | N-(2,4-Dimethylphenyl) formamide | C9H11NO | 149.08398 | Amides | 0.00 | 0.08 | | 0.10 | | 1.37 | | 0.66 | |
| 5 | Paracetamol | C8H9NO2 | 151.06325 | Amides | 0.00 | 0.00 | | 2.34 | | 11.68 | | 12.89 | |
| 6 | L-Histidine | C6H9N3O2 | 155.06941 | Amides | 0.00 | 0.00 | | 0.07 | | 1.40 | | 0.05 | |
| 7 | Formetorex | C10H13NO | 163.09966 | Amides | 0.00 | 0.43 | | 0.74 | | 5.95 | | 9.34 | |
| 8 | L-Phenylalanine | C9H11NO2 | 165.07886 | Amides | 0.00 | 0.00 | | 1.11 | | 6.05 | | 5.58 | |
| 9 | Decanamide | C10H21NO | 171.16215 | Amides | 0.15 | 0.00 | | 0.00 | | 0.15 | | 4.50 | |
| 10 | Phenacetin | C10H13NO2 | 179.09446 | Amides | 0.00 | 0.16 | | 0.38 | | 0.70 | | 1.76 | |
| 11 | Laurolactam | C12H23NO | 197.1778 | Amides | 0.00 | 0.00 | | 0.00 | | 1.73 | | 0.99 | |
| 12 | Cyclohexylamine | C6H13N | 99.10518 | Amines | 0.00 | 0.00 | | 0.00 | | 1.26 | | 0.44 | |
| 13 | o-Toluidine | C7H9N | 107.07375 | Amines | 0.00 | 0.00 | | 0.86 | | 4.71 | | 4.71 | |
| 14 | N,N-Dimethylaniline | C8H11N | 121.0892 | Amines | 0.00 | 3.27 | | 1.37 | | 4.65 | | 6.84 | |
| 15 | 2,6-Diaminotoluene | C7H10N2 | 122.08452 | Amines | 0.00 | 0.14 | | 0.95 | | 6.14 | | 3.82 | |
| 16 | 2-Amino-4-cresol | C7H9NO | 123.0685 | Amines | 0.00 | 0.14 | | 1.18 | | 6.32 | | 3.46 | |
| 17 | 6-Aminocaproic acid | C6H13NO2 | 131.09468 | Amines | 0.00 | 0.00 | | 0.19 | | 1.55 | | 1.67 | |
| 18 | Acetanilide | C8H9NO | 135.06835 | Amines | 0.00 | 0.00 | | 0.09 | | 1.69 | | 1.08 | |
| 19 | N-Benzylformamide | C8H9NO | 135.06841 | Amines | 0.00 | 0.00 | | 0.00 | | 0.00 | | 1.83 | |
| 20 | Phenylethanolamine | C8H11NO | 137.084 | Amines | 0.00 | 0.00 | | 0.10 | | 4.57 | | 2.30 | |
| 21 | Methamphetamine | C10H15N | 149.12042 | Amines | 0.00 | 1.94 | | 2.39 | | 9.03 | | 9.64 | |
| 22 | N,N-DMA | C11H17N | 163.13605 | Amines | 0.00 | 0.58 | | 0.72 | | 2.64 | | 3.04 | |
| 23 | Gabapentin | C9H17NO2 | 171.12574 | Amines | 6.63 | 0.00 | | 0.16 | | 0.40 | | 0.45 | |
| 24 | DEET | C12H17NO | 191.13083 | Amines | 0.39 | 0.18 | | 0.19 | | 0.34 | | 0.41 | |
| 25 | N-Methyl homarylamine | C11H15NO2 | 193.1101 | Amines | 0.91 | 0.32 | | 0.00 | | 0.42 | | 0.54 | |
| 26 | Dibenzylamine | C14H15N | 197.12027 | Amines | 0.18 | 0.00 | | 0.00 | | 0.00 | | 0.00 | |
| 27 | 3-Methylpyridine | C6H7N | 93.05829 | Pyridines | 0.08 | 0.00 | | 0.00 | | 0.00 | | 0.00 | |
| 28 | 3-Hydroxy-2-methylpyridine | C6H7NO | 109.05301 | Pyridines | 0.00 | 0.20 | | 2.07 | | 22.63 | | 0.00 | |
| 29 | 3-Hydroxypicolinic acid | C6H5NO3 | 139.02686 | Pyridines | 0.00 | 0.00 | | 0.25 | | 2.39 | | 0.48 | |
| 30 | Pyridoxal | C8H9NO3 | 167.05815 | Pyridines | 0.00 | 0.00 | | 0.35 | | 2.15 | | 2.66 | |
| 31 | Pyridoxine | C8H11NO3 | 169.0737 | Pyridines | 0.00 | 0.00 | | 0.42 | | 0.72 | | 0.00 | |
| 32 | Pyrrole-2-carboxylic acid | C5H5NO2 | 111.03221 | Pyrroles | 0.00 | 0.00 | | 0.65 | | 2.21 | | 1.42 | |
| 33 | N-Vinyl-2-pyrrolidone | C6H9NO | 111.06865 | Pyrroles | 0.00 | 0.06 | | 0.11 | | 0.91 | | 1.37 | |
| 34 | 4-Piperidone | C5H9NO | 99.06877 | Others | 0.00 | 0.33 | | 1.23 | | 4.22 | | 5.88 | |
| 35 | Choline | C5H13NO | 103.1 | Others | 1.43 | 1.18 | | 1.21 | | 1.24 | | 1.30 | |
| 36 | 2,5-Dimethylpyrazine | C6H8N2 | 108.06903 | Others | 0.00 | 0.00 | | 0.12 | | 0.86 | | 0.75 | |
| 37 | Betaine | C5H11NO2 | 117.0791 | Others | 0.00 | 0.15 | | 0.00 | | 0.00 | | 0.00 | |
| 38 | Pipecolic acid | C6H11NO2 | 129.07911 | Others | 0.00 | 0.00 | | 0.00 | | 0.00 | | 0.50 | |
| 39 | 4-Hydroxyindole | C8H7NO | 133.05266 | Others | 0.00 | 0.00 | | 0.37 | | 2.32 | | 0.62 | |
| 40 | N,N,4-Trimethylaniline | C9H13N | 135.10475 | Others | 0.00 | 0.09 | | 0.19 | | 0.64 | | 0.00 | |
| 41 | 5,6-Dimethylbenzimidazole | C9H10N2 | 146.0843 | Others | 0.00 | 0.28 | | 0.10 | | 0.94 | | 2.77 | |
| 12 | Acetyl-β-methylcholine | C8H17NO2 | 159.12573 | Others | 0.00 | 22.30 | | 0.00 | | 0.00 | | 0.00 | |
| 43 | 3-(2-Hydroxyethyl)indole | C10H11NO | 161.08393 | Others | 0.00 | 0.00 | | 0.00 | | 0.33 | | 0.15 | |
| 44 | Nicotine | C10H14N2 | 162.11573 | Others | 0.24 | 0.13 | | 0.00 | | 0.00 | | 0.00 | |
| 45 | Perillartine | C10H15NO | 165.11527 | Others | 0.00 | 0.00 | | 0.00 | | 0.00 | | 3.71 | |
| 46 | Indole-3-acrylic acid | C11H9NO2 | 187.0632 | Others | 0.00 | 0.00 | | 0.08 | | 0.24 | | 0.51 | |







Fig. S1 FTIR spectrum of the gases from different substrate at specific temperature. (a) Sewage sludge. (b) PAM. (c) The mixture of sewage sludge and PAM.