

Supplementary Materials for **One-pot synthesis of amino acid precursors with insoluble organic matter in planetesimals with aqueous activity**

Yoko Kebukawa, Queenie H. S. Chan, Shogo Tachibana, Kensei Kobayashi, Michael E. Zolensky

Published 17 March 2017, *Sci. Adv.* **3**, e1602093 (2017)

DOI: 10.1126/sciadv.1602093

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- fig. S5. Mass spectra of the OPA/NAC-derivatized amino acids with an m/z of 337.0858 (corresponds to glycine), 351.1015 (alanine), 365.1171 (C4 amino acids; for example, AIB), 367.0964 (serine), 379.1328 (C5 amino acids; for example, valine), 381.112 (threonine), 393.1484 (C6 amino acids; for example, leucine), 395.0913 (aspartic acid), and 409.1069 (glutamic acid).
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Supplementary Materials

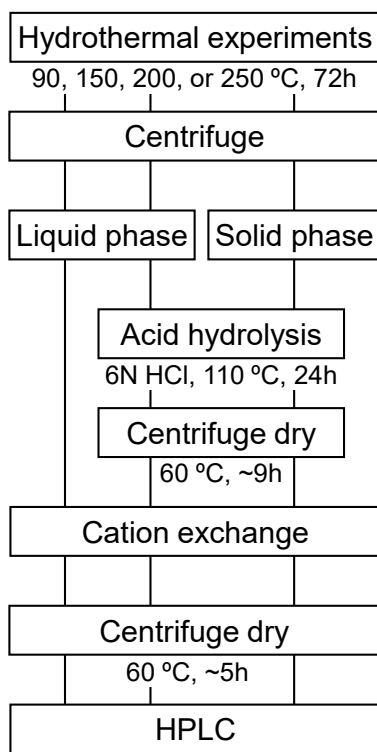


fig. S1. Experimental and analytical scheme.

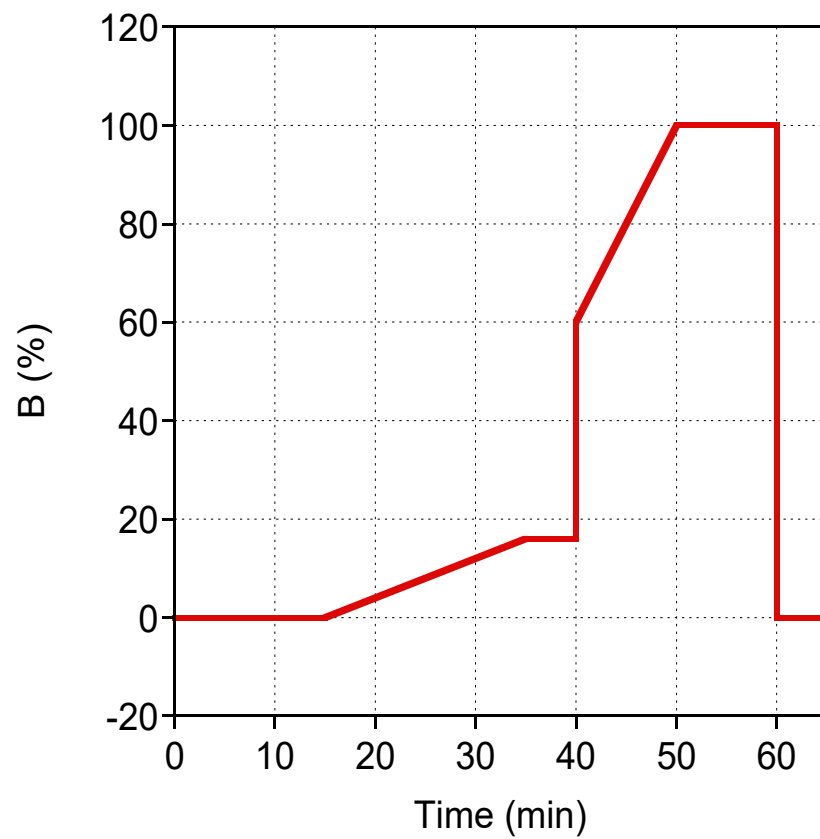
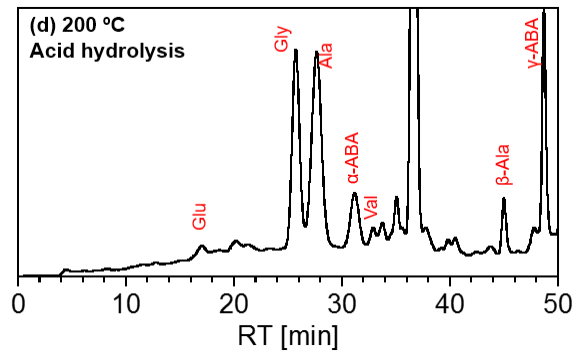
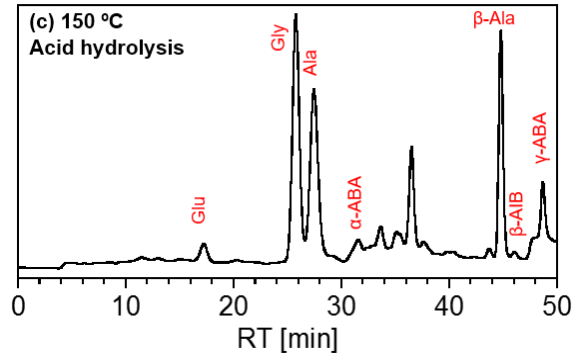
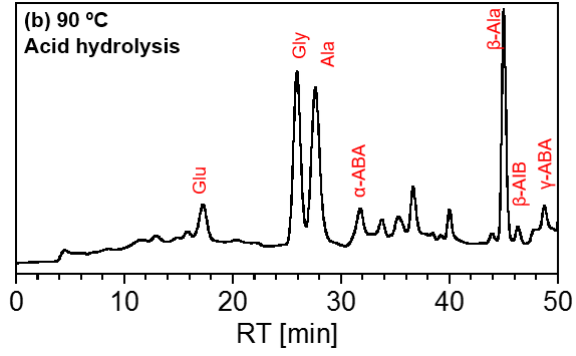
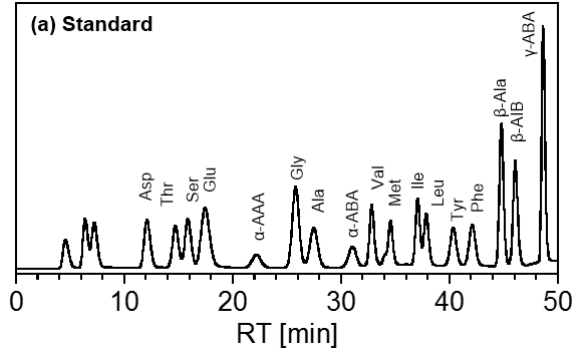


fig. S2. Mobile phase gradient for the amino acid analyses.



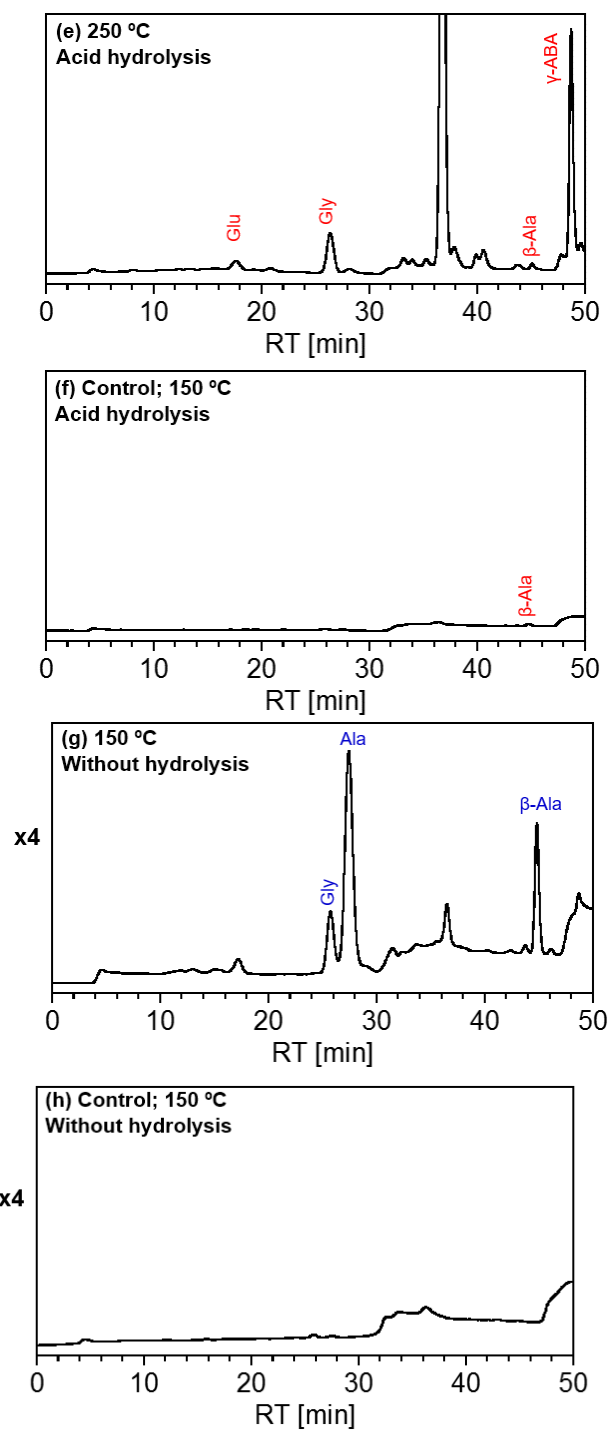


fig. S3. HPLC chromatograms of amino acids in the standard solution and the reaction products from the hydrothermal experiments. The control sample is obtained with the same experimental conditions without adding ammonia. Abbreviations; Gly: glycine, Ala: alanine, ABA: aminobutyric acid, AIB: aminoisobutyric acid, Glu: glutamic acid, Val: valine.

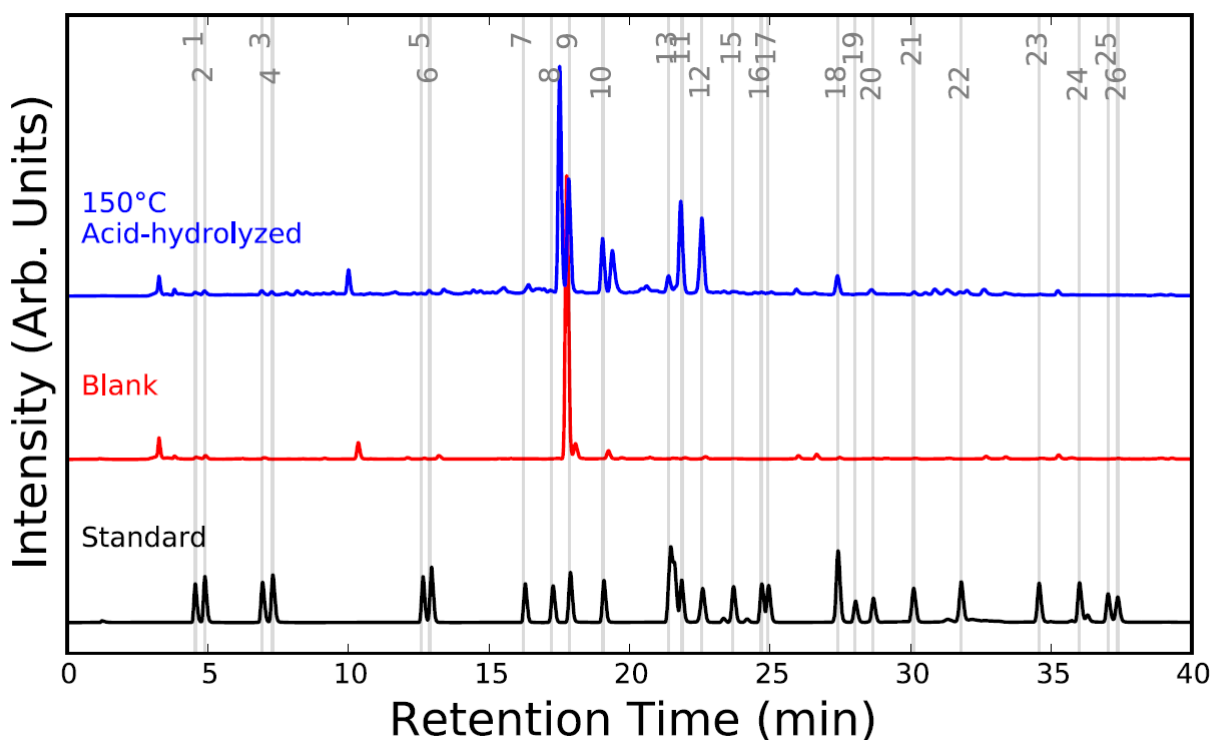


fig. S4. The 0- to 40-min region of the UPLC-FD chromatograms for the 6 M HCl acid-hydrolyzed reaction product solution from the hydrothermal experiment containing ammonia, formaldehyde, and glycolaldehyde heated at 150°C for 72 hours, the control blank sample, and the amino acid standard solution, measured at NASA JSC. The peaks were identified by comparison of the retention time and exact molecular mass to those in the amino acid standard. The peak numbers correspond to the amino acids listed in Table 1.

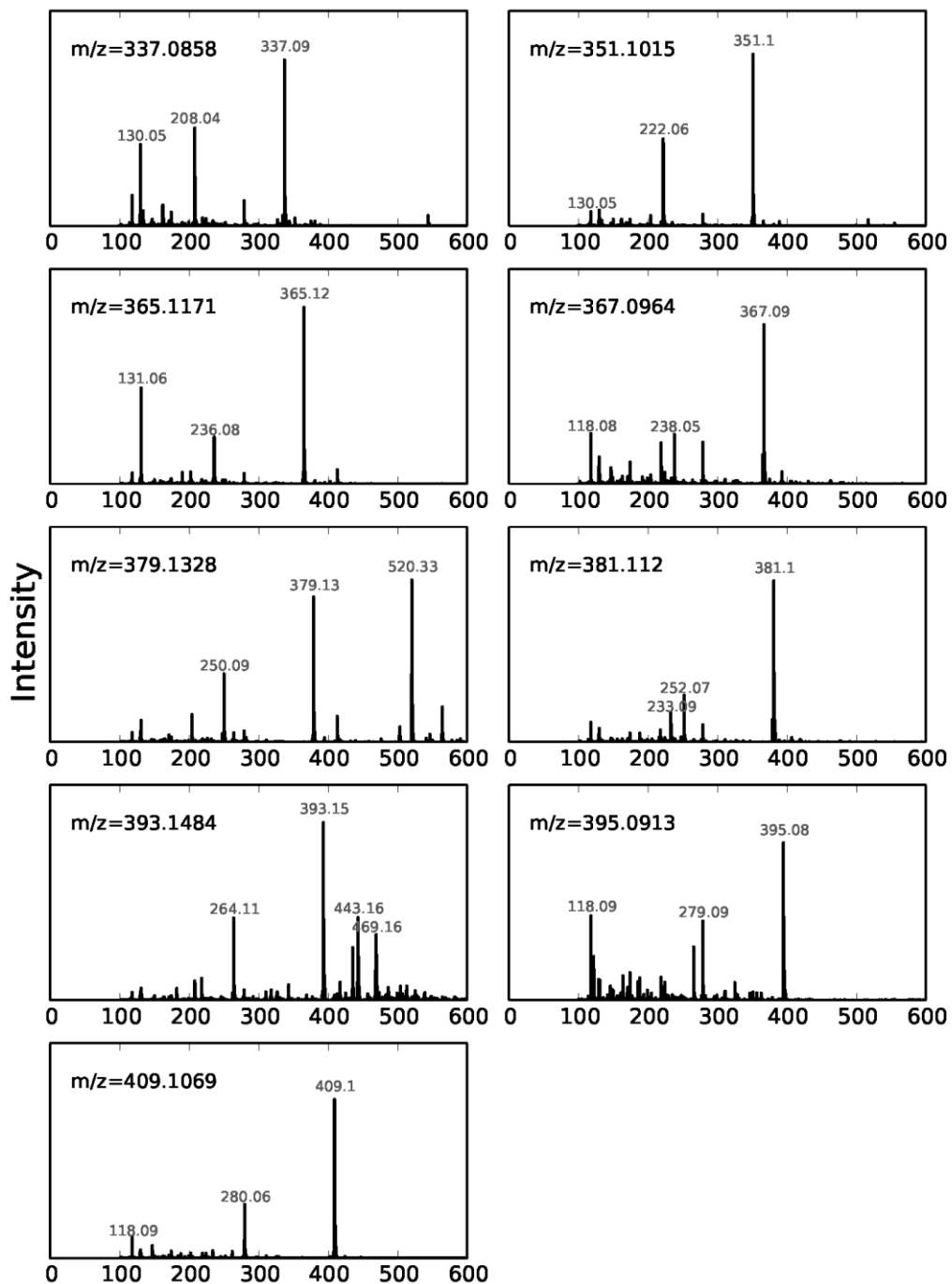


fig. S5. Mass spectra of the OPA/NAC-derivatized amino acids with an m/z of 337.0858 (corresponds to glycine), 351.1015 (alanine), 365.1171 (C4 amino acids; for example, AIB), 367.0964 (serine), 379.1328 (C5 amino acids; for example, valine), 381.112 (threonine), 393.1484 (C6 amino acids; for example, leucine), 395.0913 (aspartic acid), and 409.1069 (glutamic acid).

table S1. Wako Amino Acids Mixture Standard Solution (0.1 M HCl).

Type B	$\mu\text{mol/ml}$	Type AN-2	$\mu\text{mol/ml}$
DL-plus allo- δ -hydroxylysine	2.50	o-Phosphoserine	1.25
γ -Aminobutyric acid	2.50	o-Phosphoethanolamine	1.25
L-Ornithine	2.50	Taurine	1.25
Ethanolamine	2.50	Urea	50.00
Ammonium chloride	2.50	Hydroxy-L-proline	2.50
L-Lysine	2.50	L-Aspartic acid	2.50
L-Histidine	2.50	L-Serine	2.50
L-3-Methylhistidine	2.50	Sarcosine	6.25
L-Anserine	2.50	L-Proline	2.50
L-Carnosine	2.50	L-Glutamic acid	2.50
L-Arginine	2.50	L-Citrulline	2.50
L-1-Methylhistidine	2.50	Glycine	2.50
		L-Alanine	2.50
		L- α -Aminoadipic acid	1.25
		DL- α -Amino-n-butyric acid	1.25
		L-Valine	2.50
		L-Cystine	2.50
		L-Cystathionine	1.25
		L-Methionine	2.50
		L-Isoleucine	2.50
		L-Leucine	2.50
		L-Tyrosine	2.50
		L-Phenylalanine	2.50
		β -Alanine	2.50
		DL- β -Aminoisobutyric acid	2.50
		L-Threonine	2.50