

Supplementary Materials for

Trimetaphosphate activates prebiotic peptide synthesis

across a wide range of temperature and pH

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Fig. S32-S43. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at different pH as a function of temperature.

Fig. S44- S56. Mass spectra for obtained oligomers.

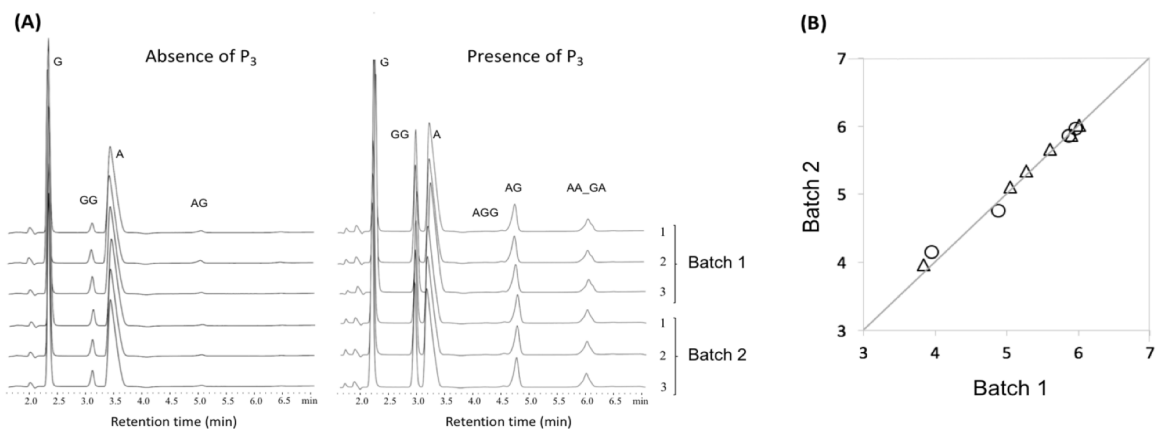


Figure S1. Reproducibility of experiments. Reactions were performed with three replicates per batch, with batches run on two different days. **(A)** HPLC product profiles are shown for reactions run in the absence and presence of trimetaphosphate (TP). The **(B)** concentrations for each peptide species were determined and plotted for batch 2 versus batch 1 in the absence (circles) and presence (triangles) of TP. Reactions of glycine and alanine were carried out at pH and 60°C, and concentrations are $\log_{10}(\mu\text{M})$; for example, a value of 4 corresponds to $10^4 \mu\text{M}$ or 10 mM.

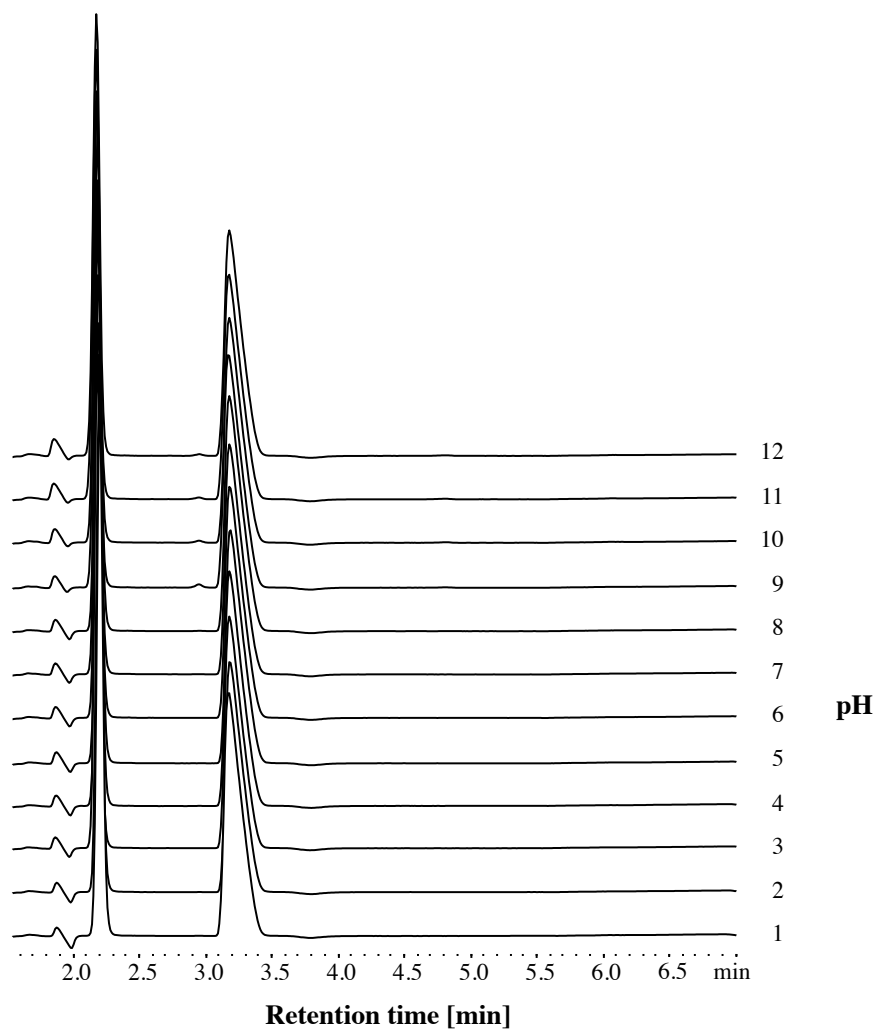


Fig. S2. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the absence of TP at 40°C as a function of pH.

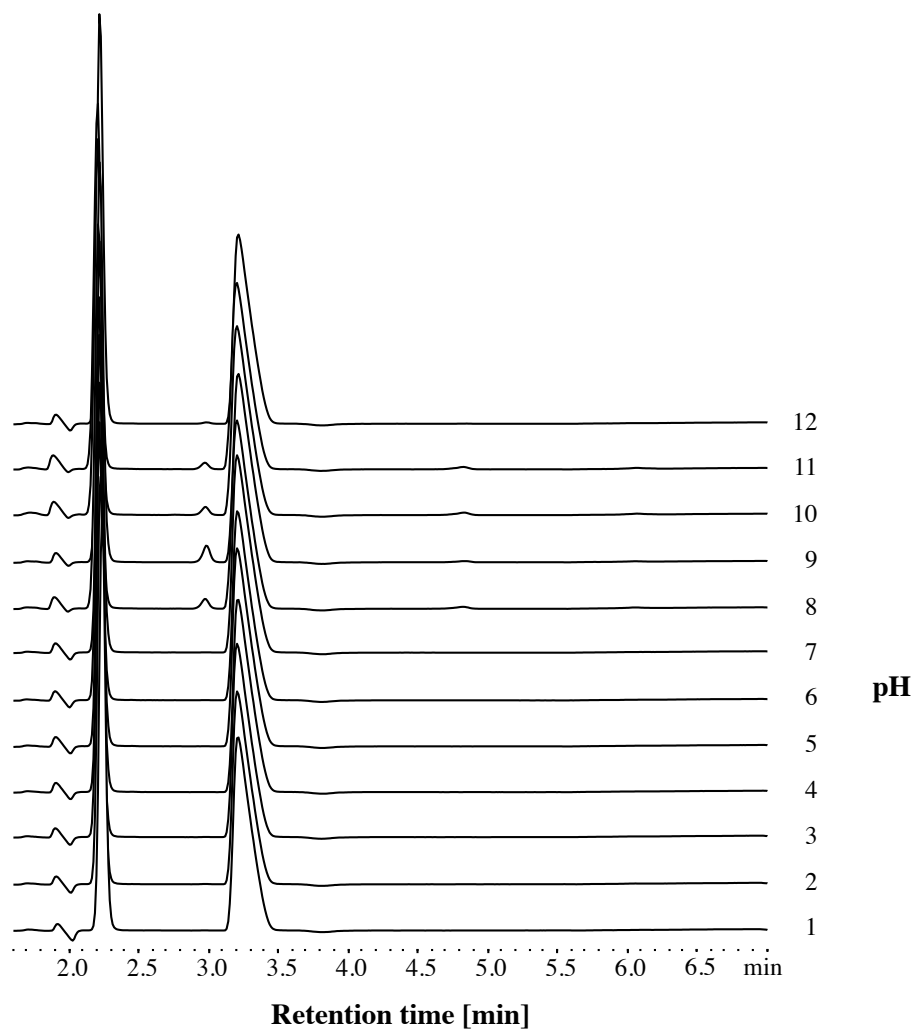


Fig. S3. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the absence of TP at 50°C as a function of pH.

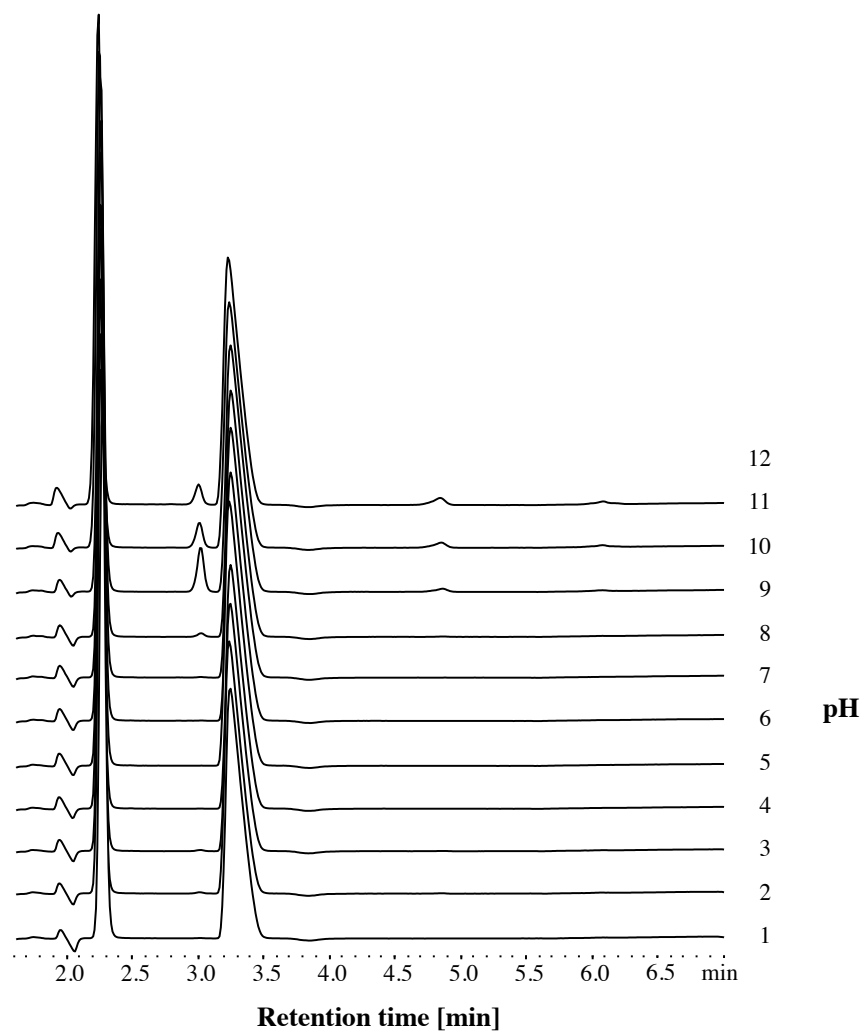


Fig. S4. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the absence of TP at 60°C as a function of pH.

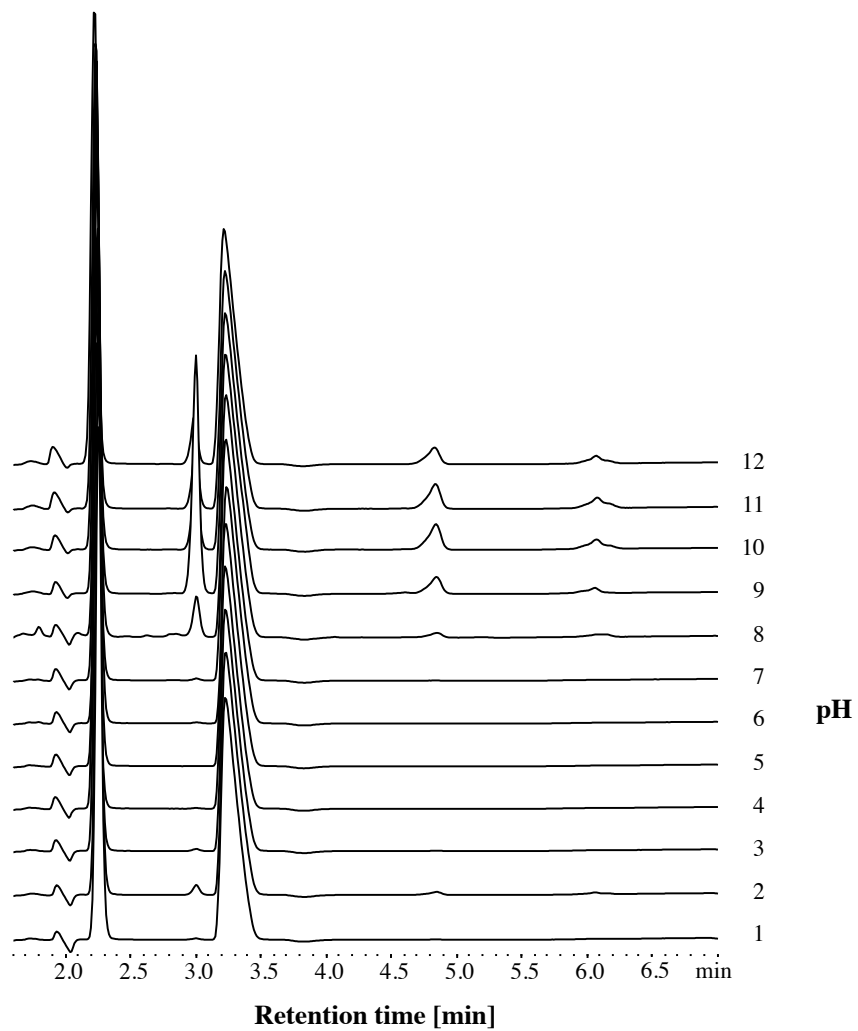


Fig. S5. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the absence of TP at 70°C as a function of pH.

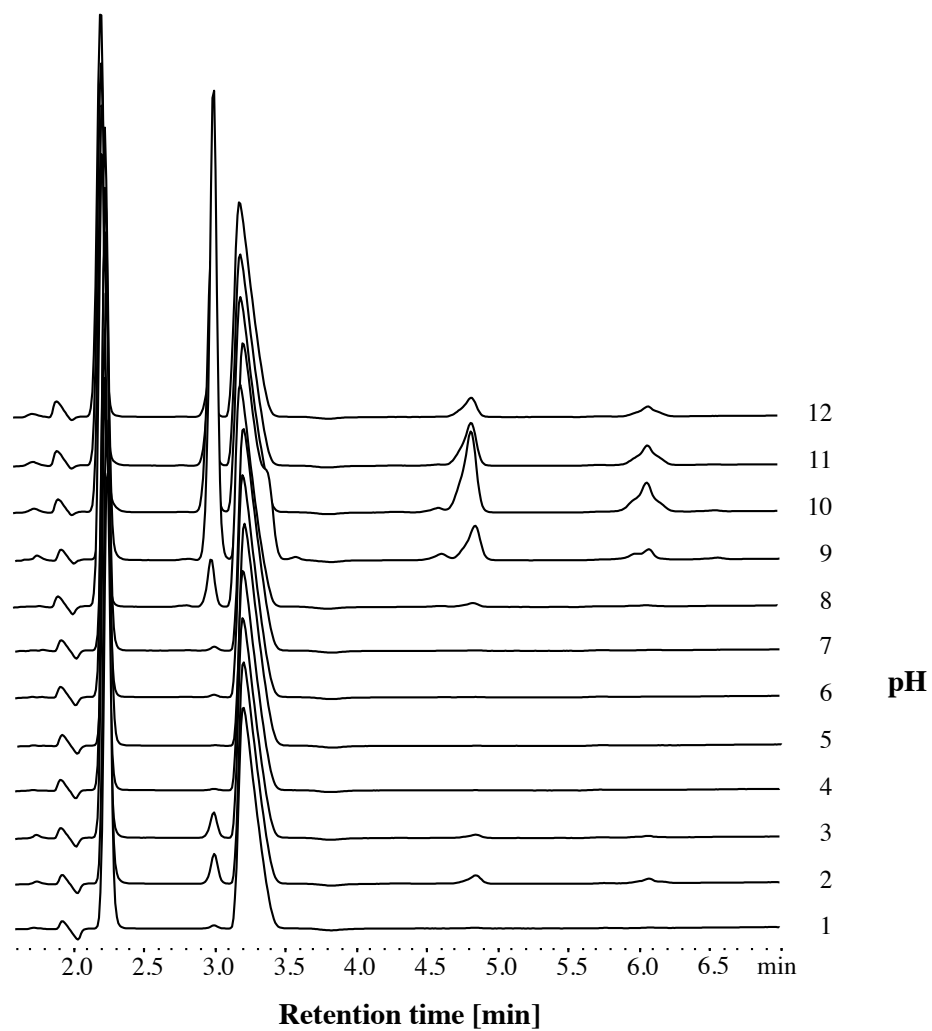


Fig. S6. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the absence of TP at 80°C as a function of pH.

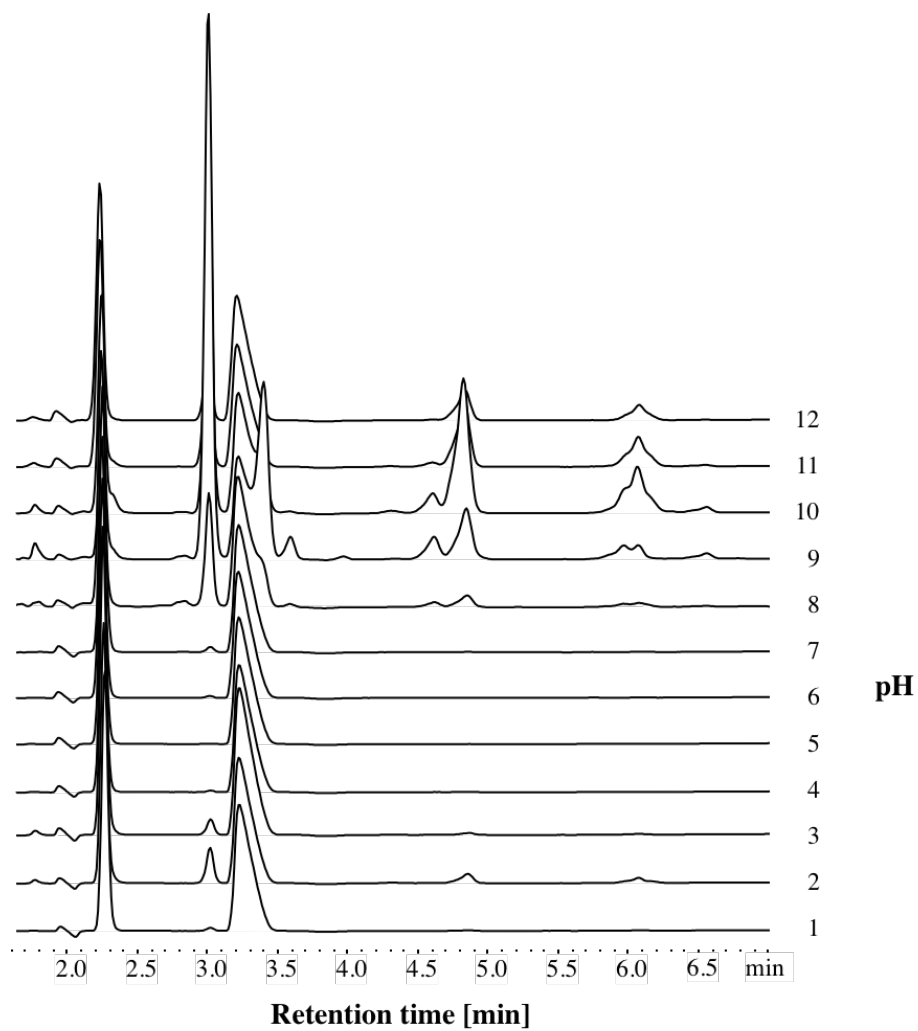


Fig. S7. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the absence of TP at 90°C as a function of pH.

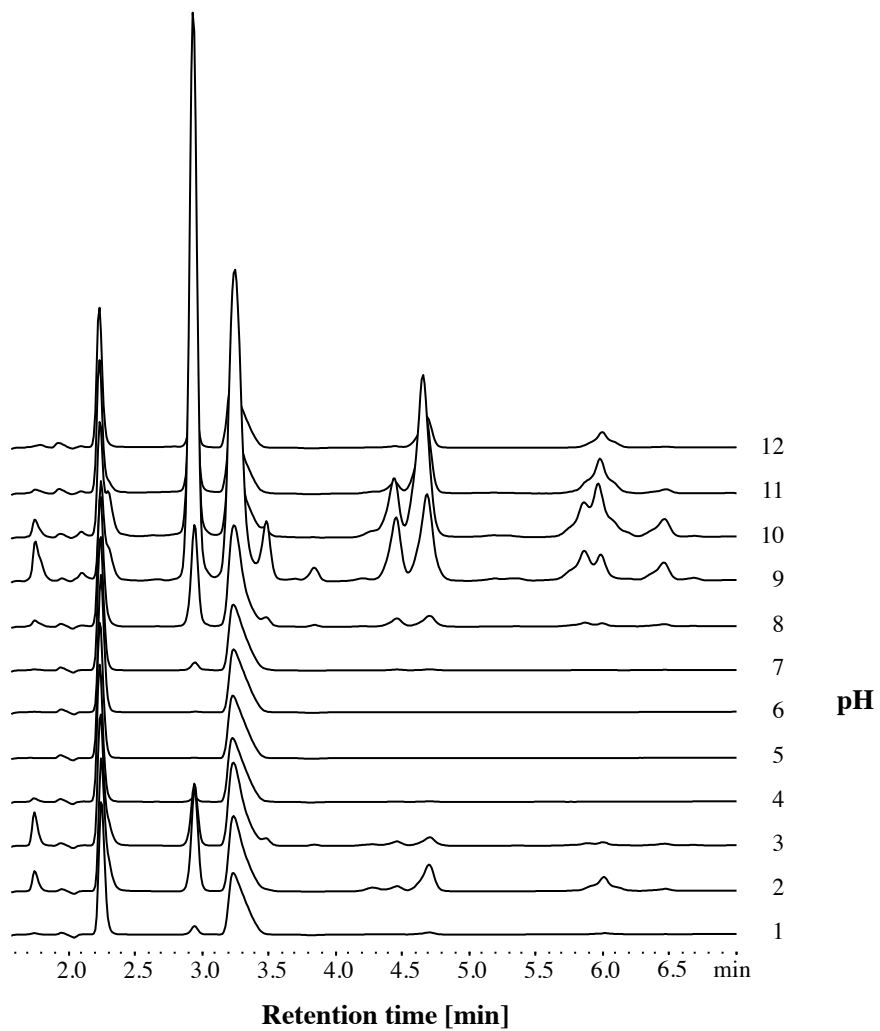


Fig. S8. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the absence of TP at 100°C as a function of pH.

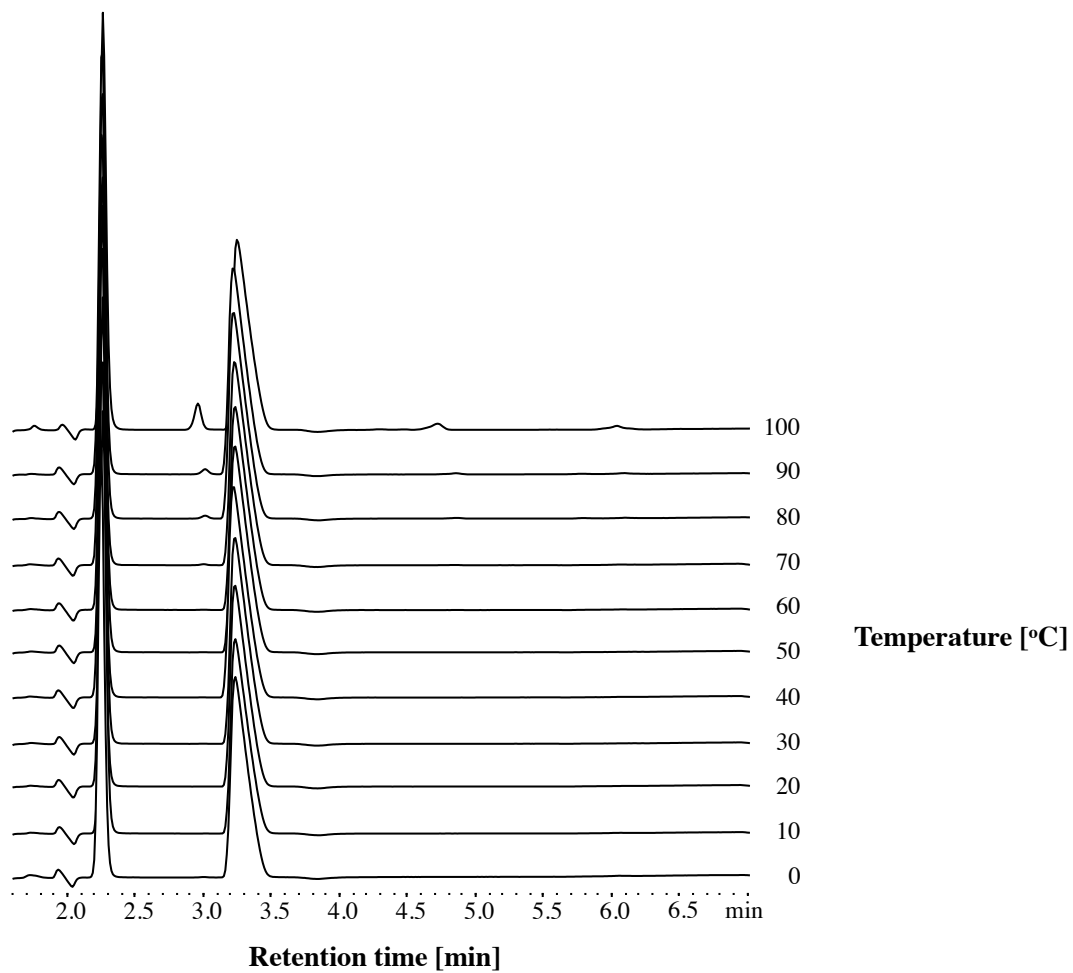


Fig. S9. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the absence of TP at pH 1 as a function of temperature.

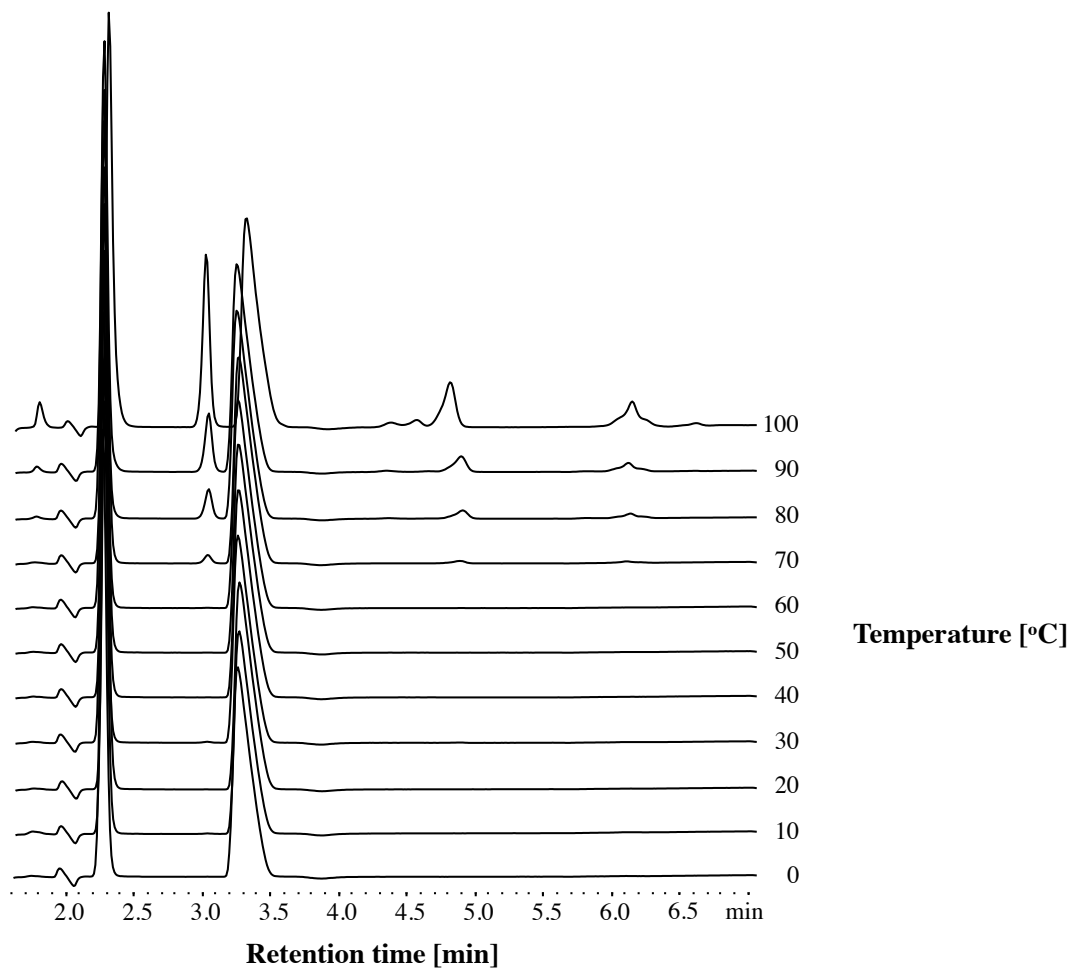


Fig. S10. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the absence of TP at pH 2 as a function of temperature.

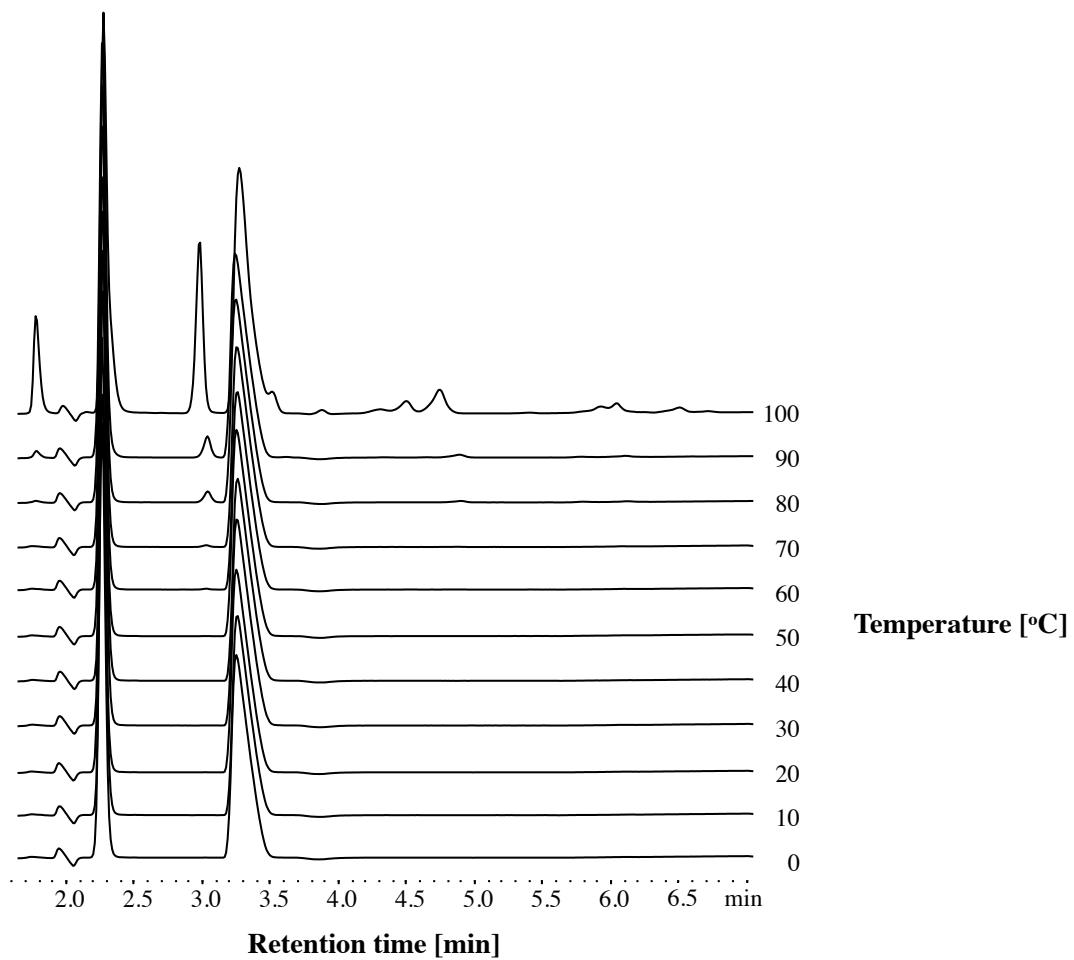


Fig. S11. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the absence of TP at pH 3 as a function of temperature.

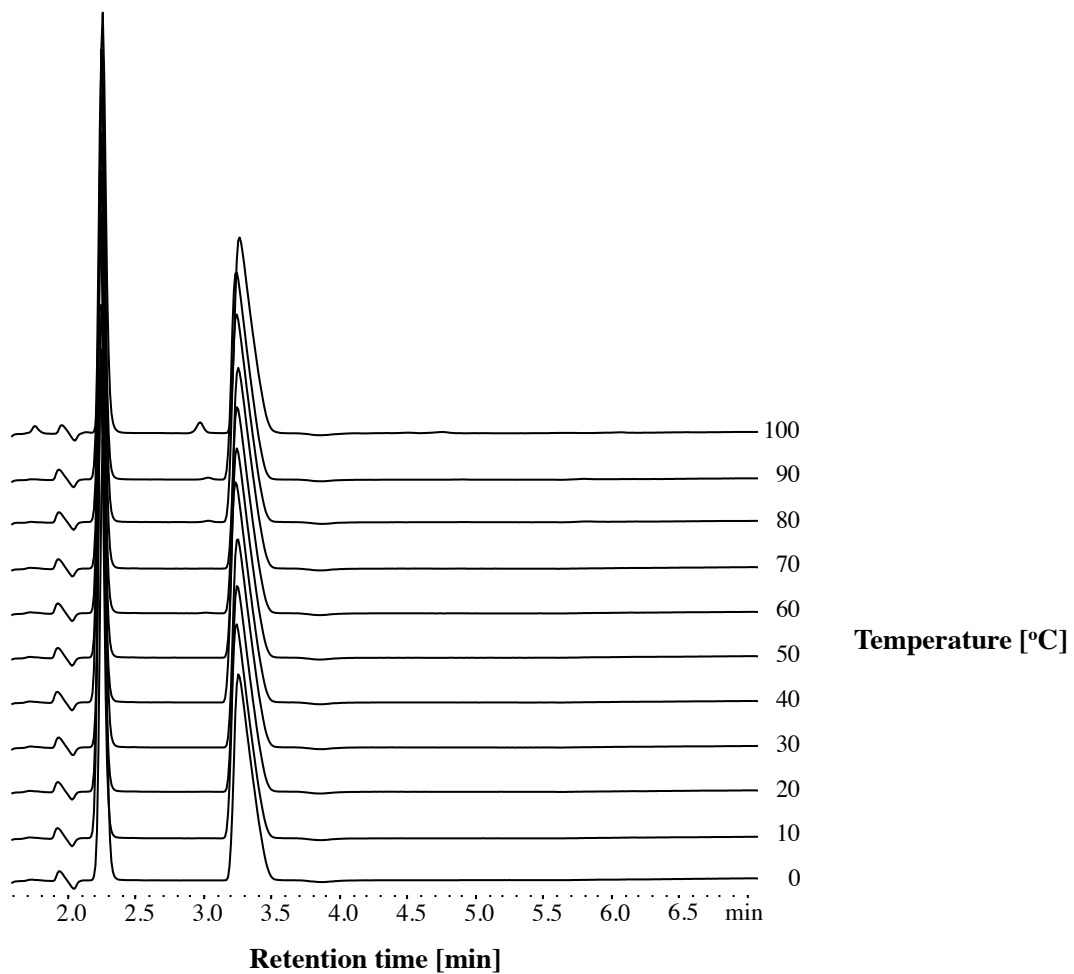


Fig. S12. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the absence of TP at pH 4 as a function of temperature.

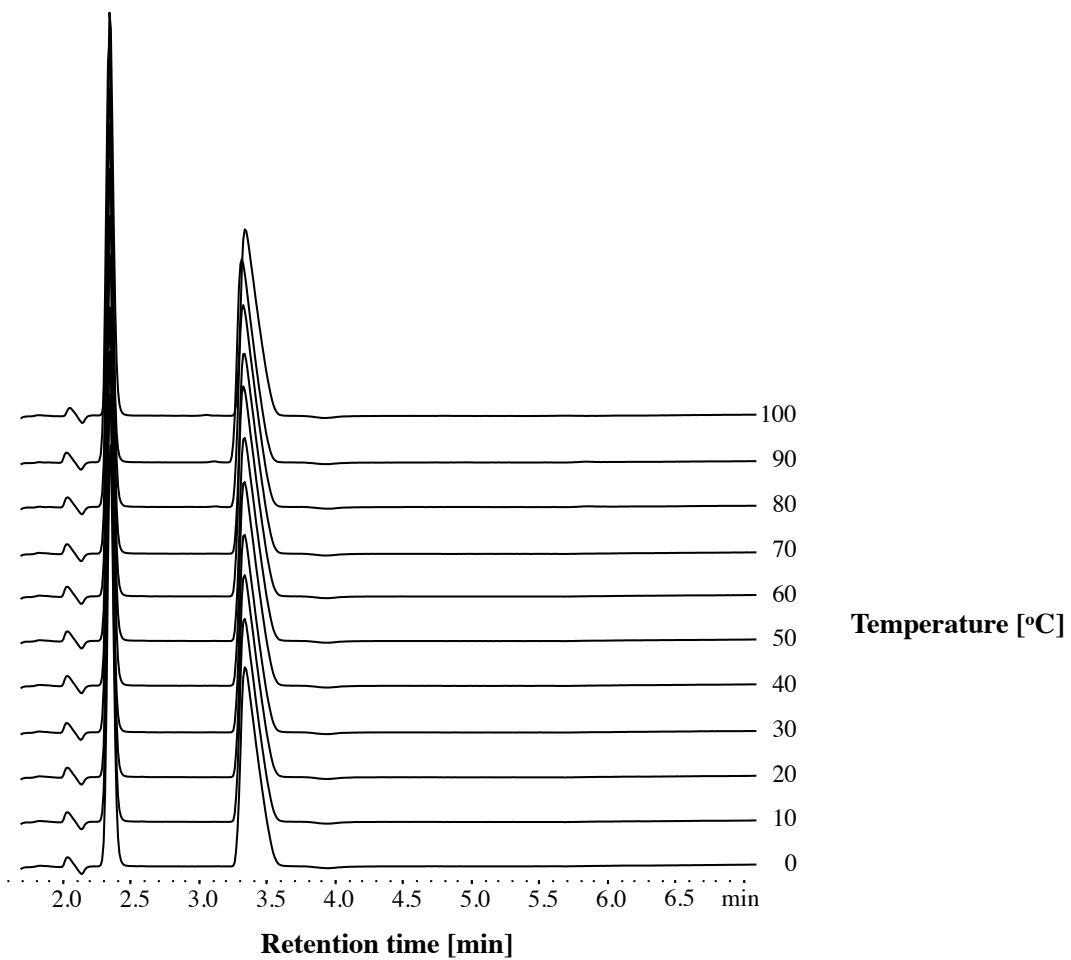


Fig. S13. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the absence of TP at pH 5 as a function of temperature.

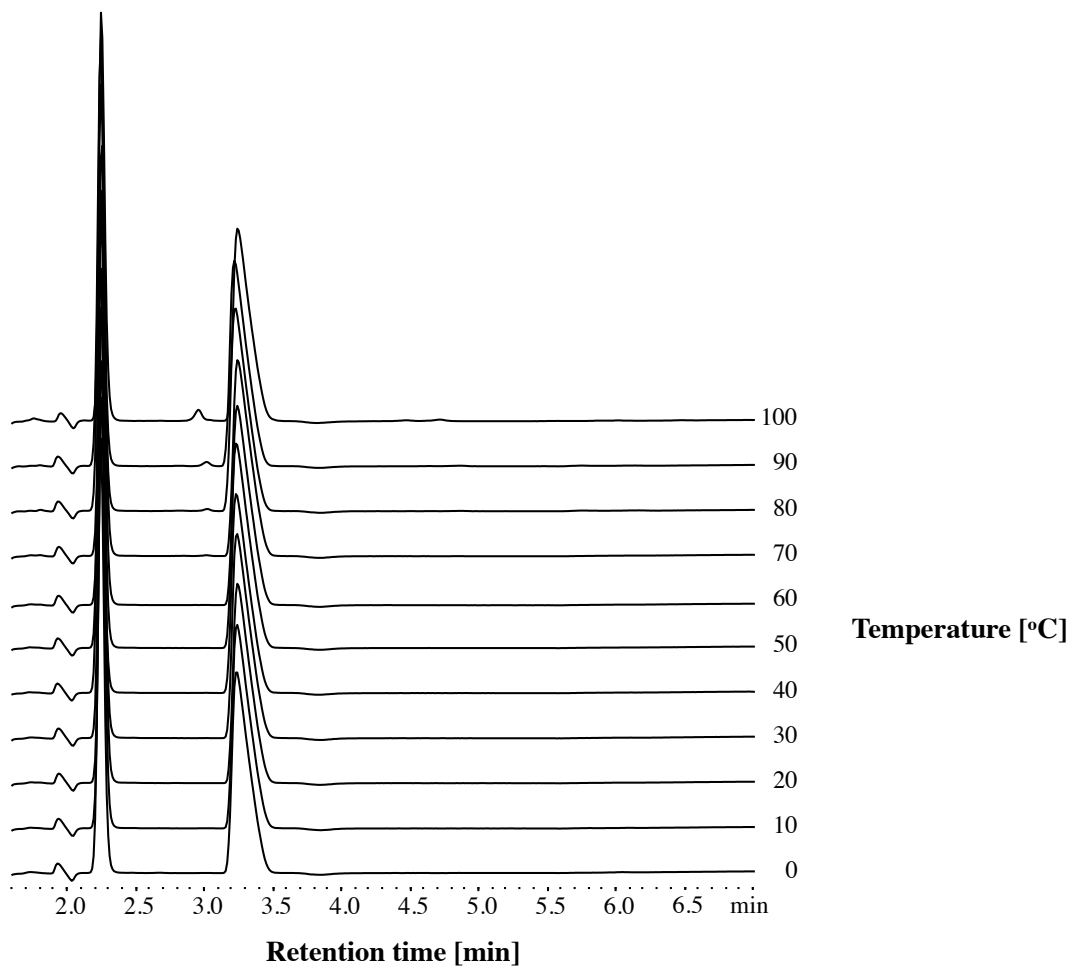


Fig. S14. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the absence of TP at pH 6 as a function of temperature.

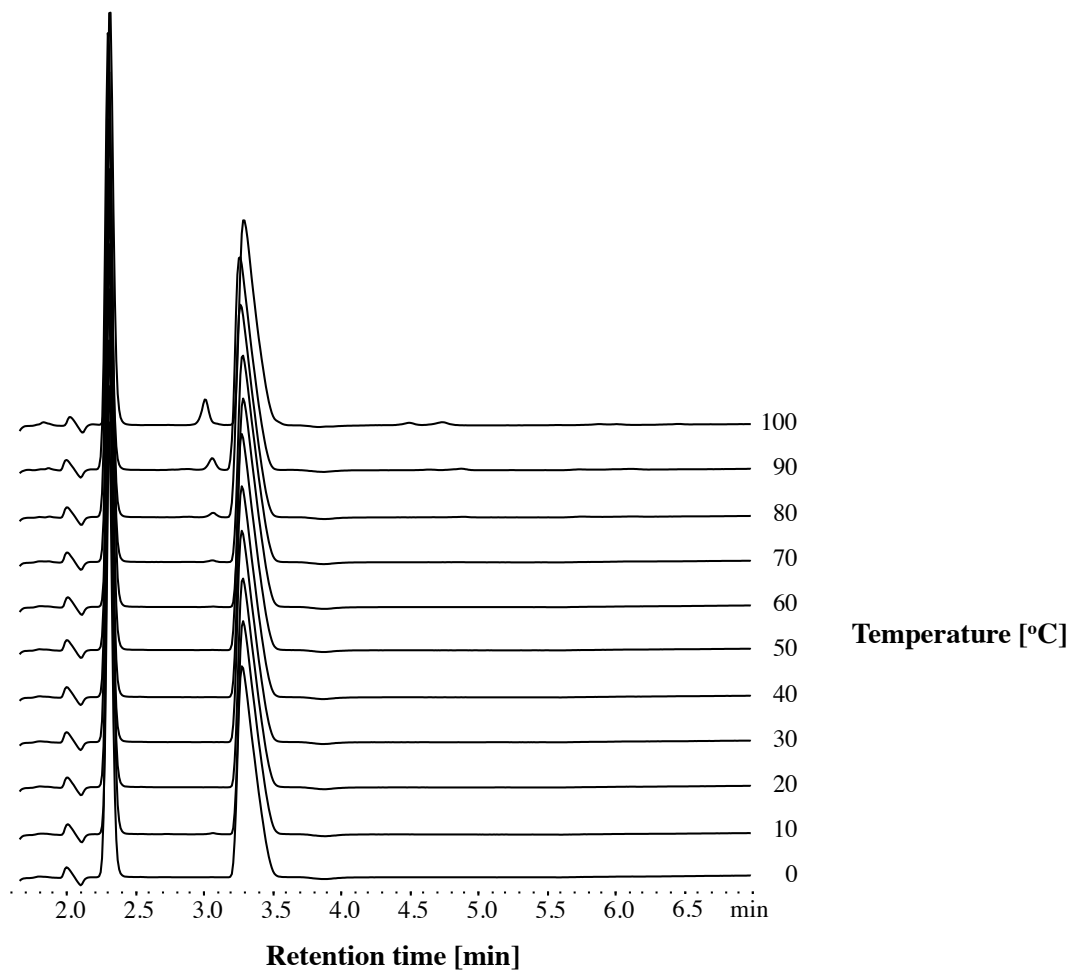


Fig. S15. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the absence of TP at pH 7 as a function of temperature.

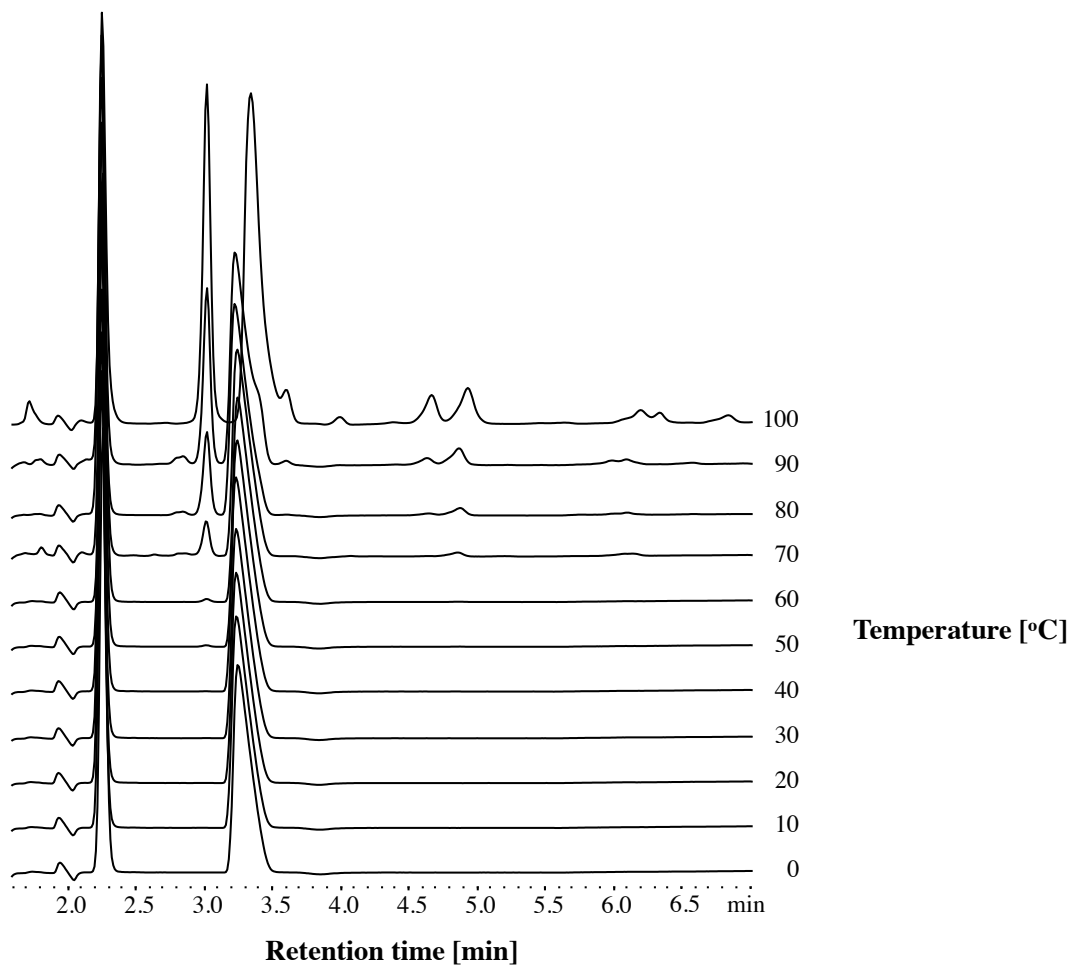


Fig. S16. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the absence of TP at pH 8 as a function of temperature.

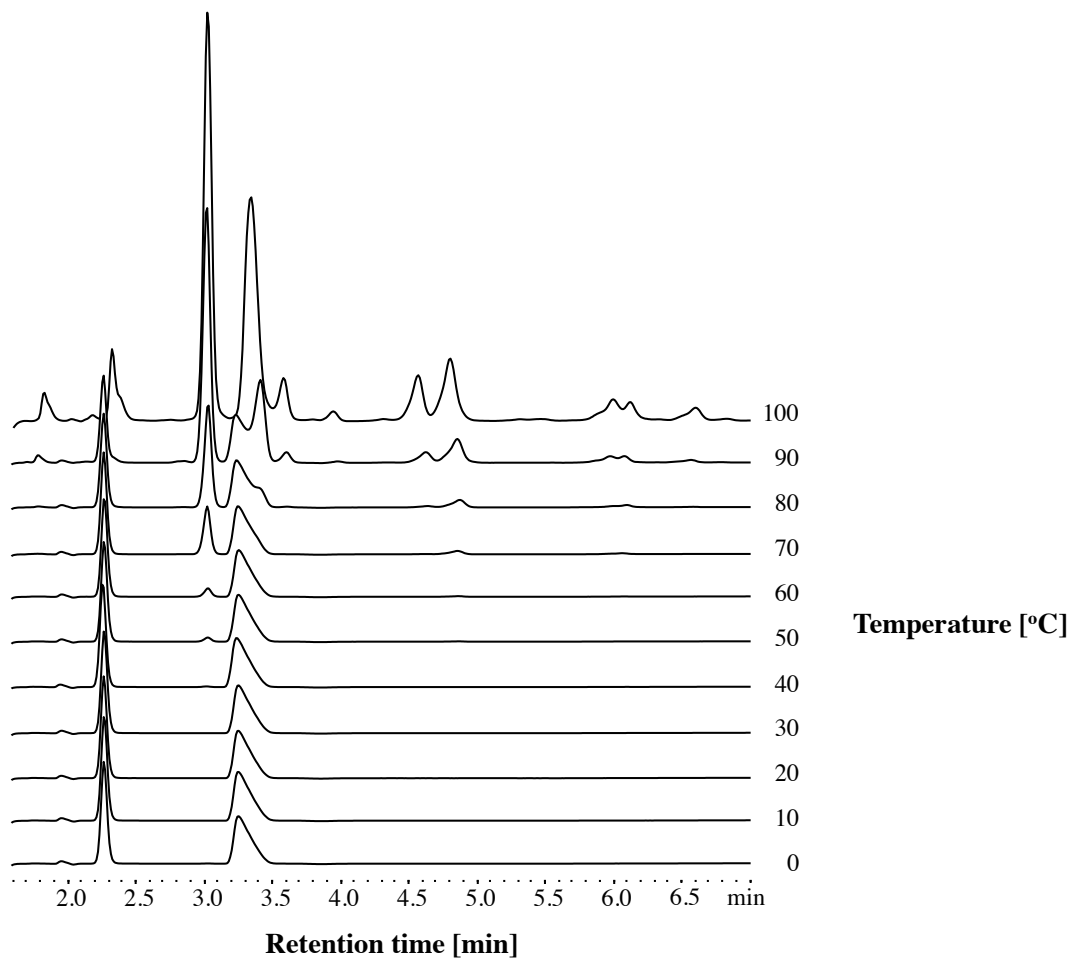


Fig. S17. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the absence of TP at pH 9 as a function of temperature.

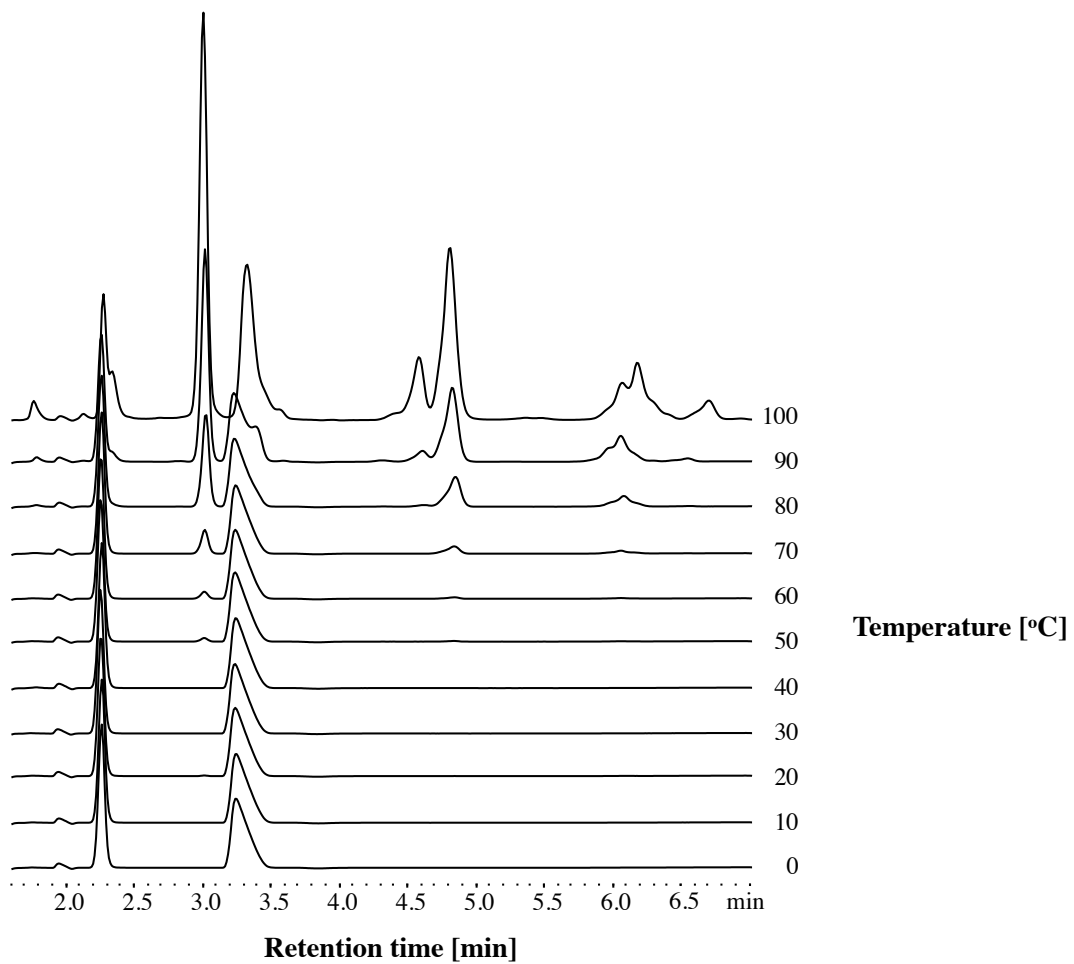


Fig. S18. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the absence of TP at pH 10 as a function of temperature.

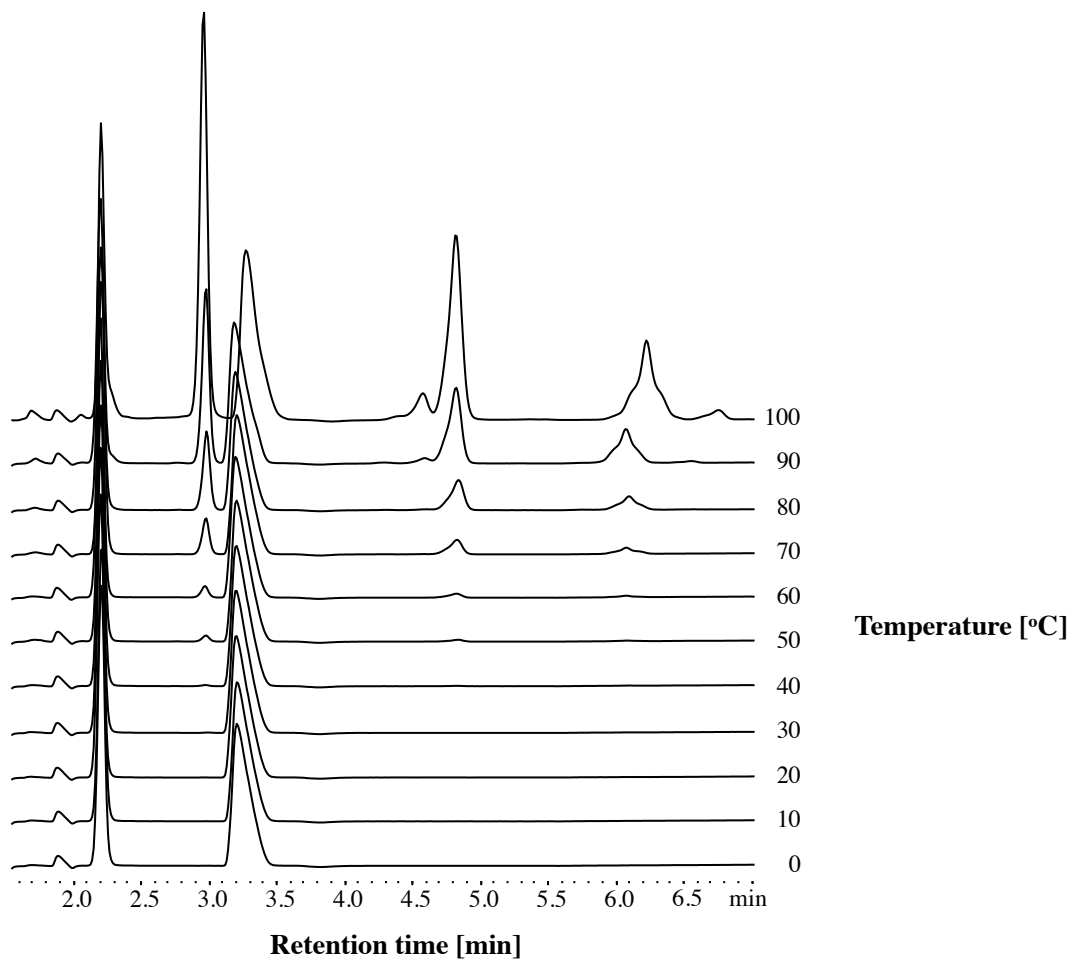


Fig. S19. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the absence of TP at pH 11 as a function of temperature.

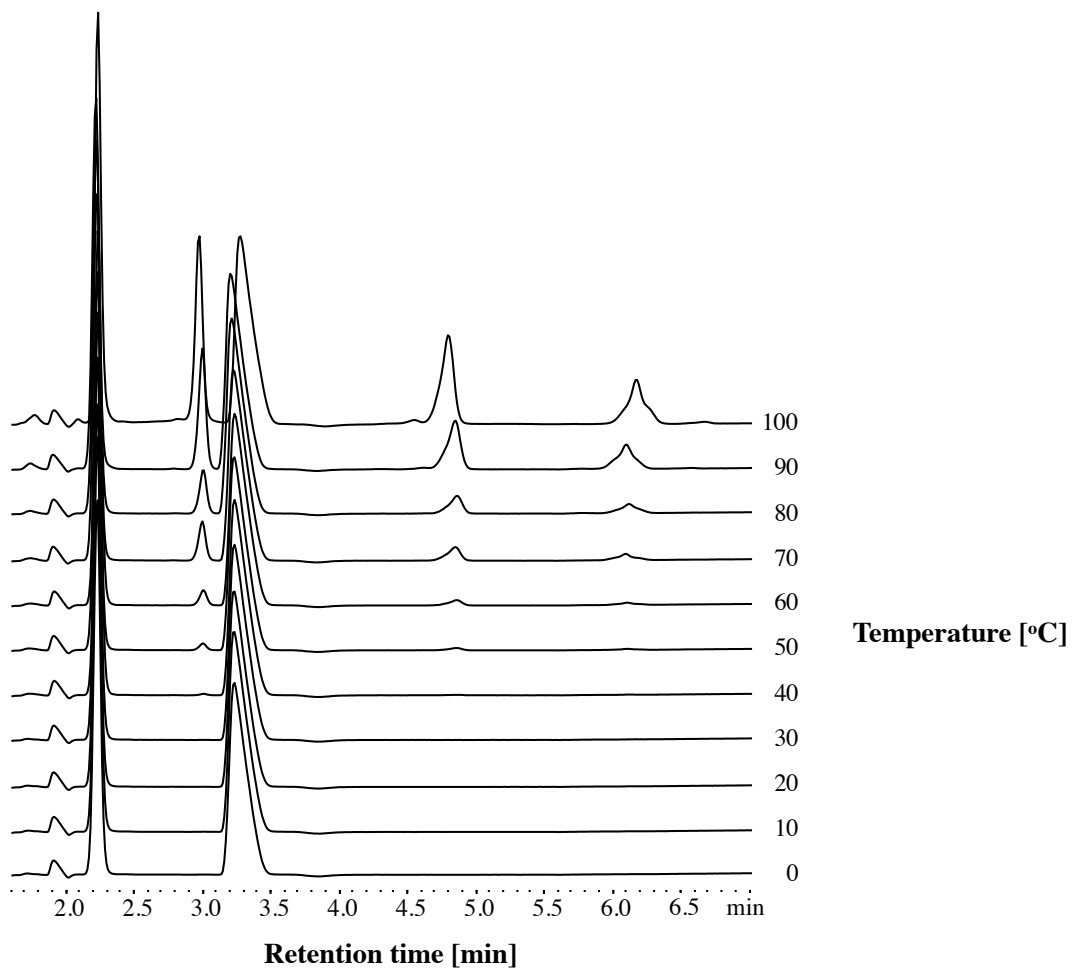


Fig. S20. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the absence of TP at pH 12 as a function of temperature.

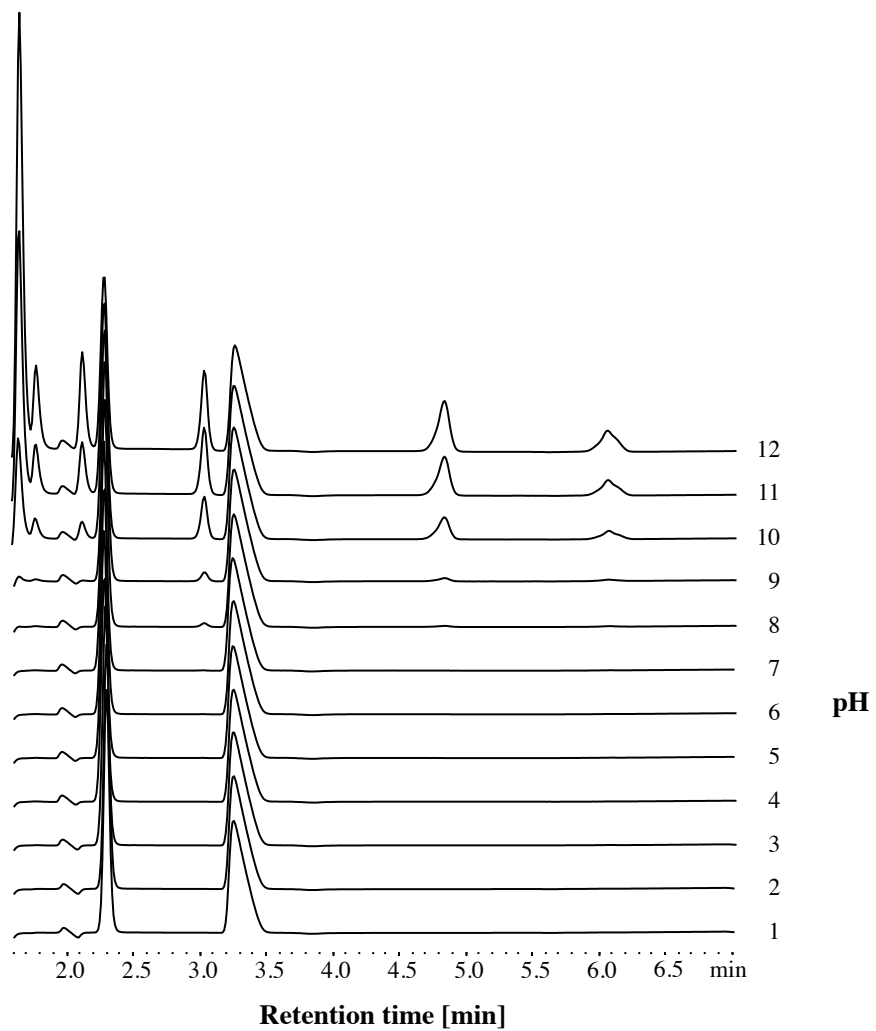


Fig. S21. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at 0°C as a function of pH.

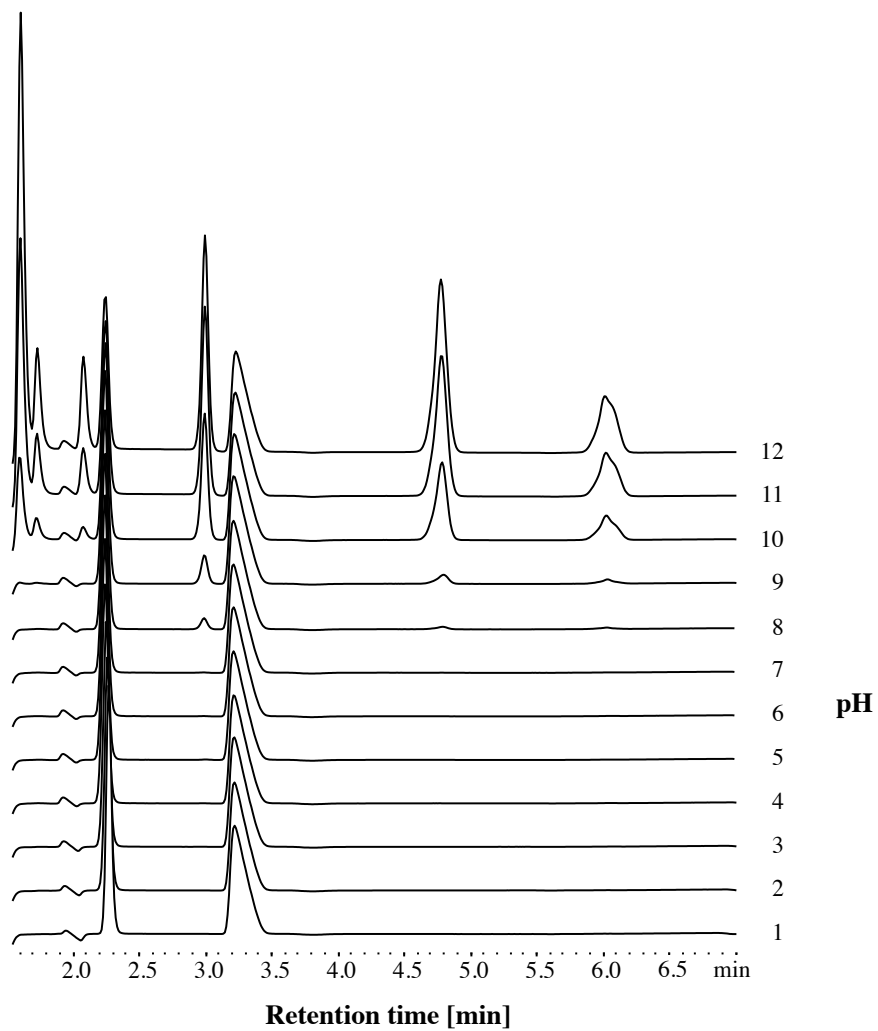


Fig. S22. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at 10°C as a function of pH.

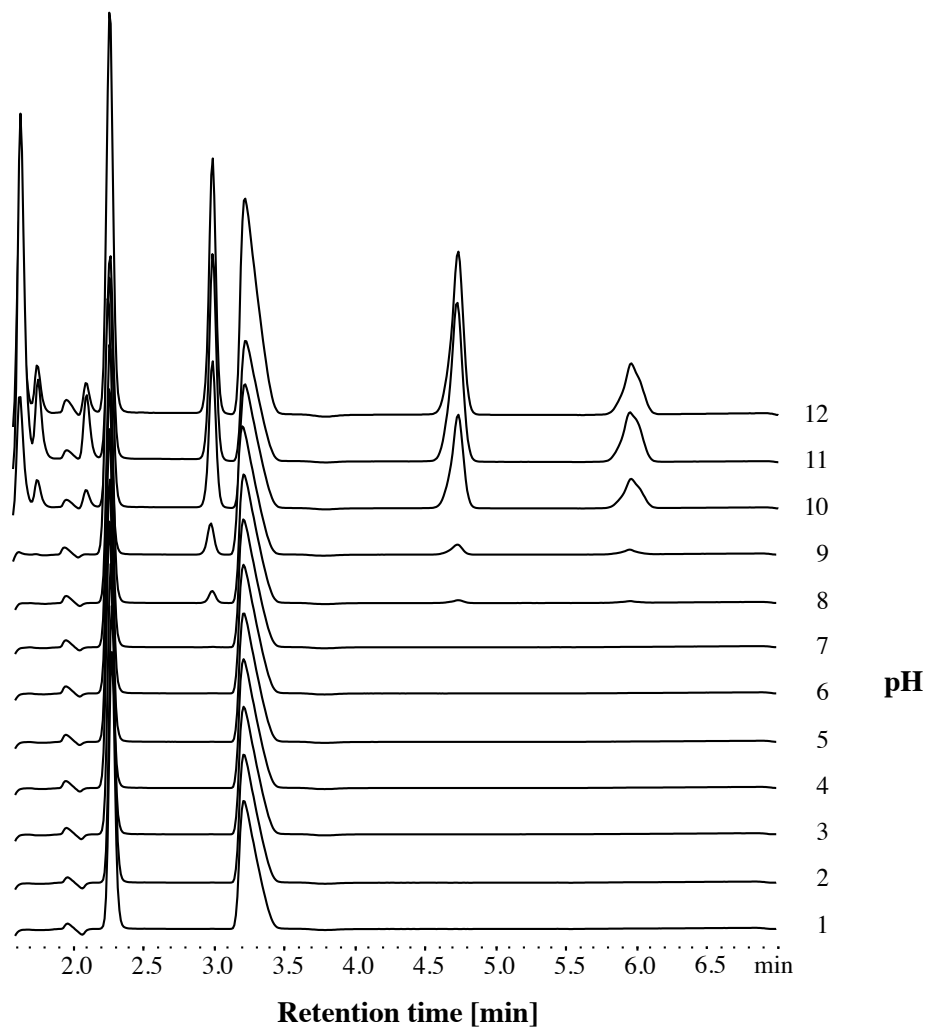


Fig. S23. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at 20°C as a function of pH.

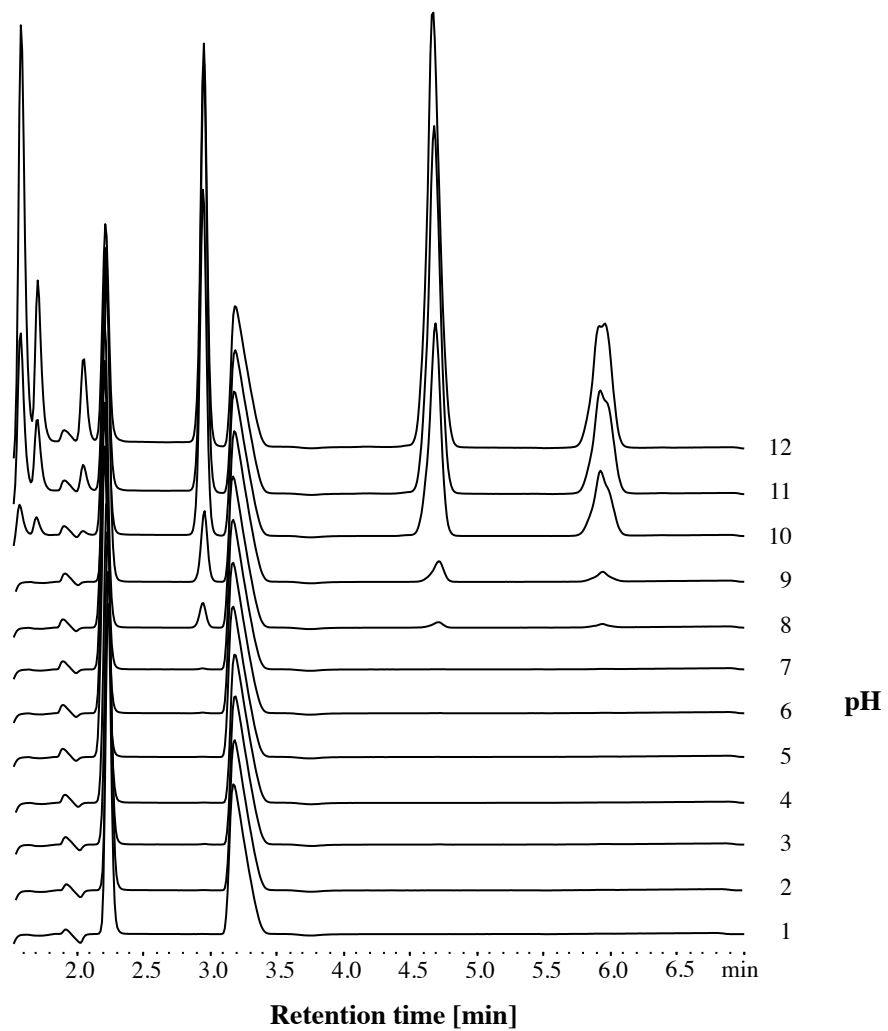


Fig. S24. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at 30°C as a function of pH.

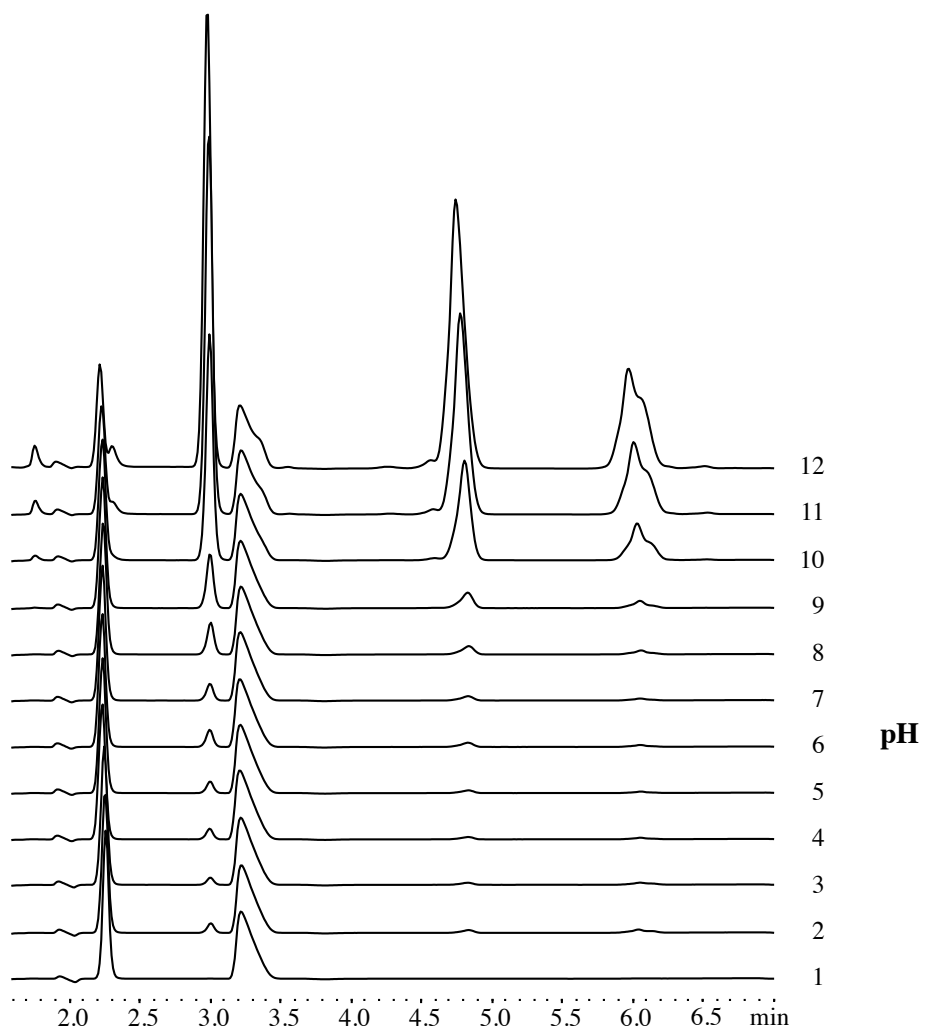


Fig. S25. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at 40°C as a function of pH.

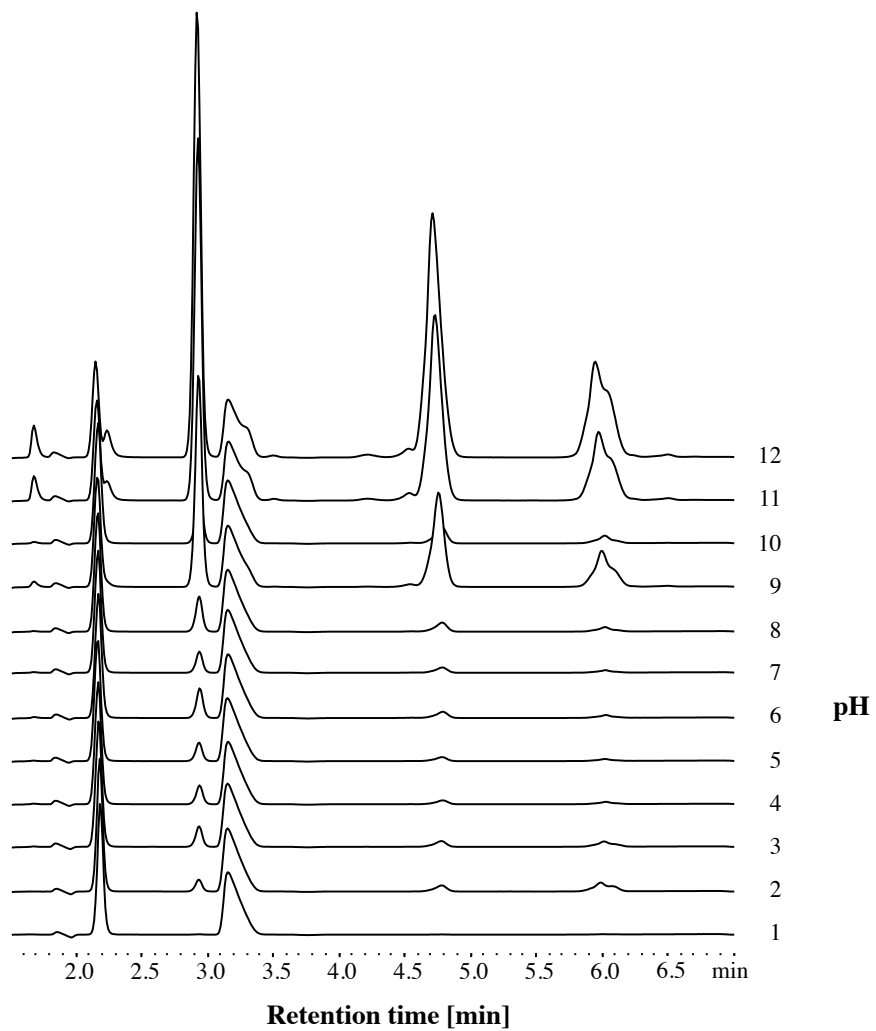


Fig. S26. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at 50°C as a function of pH.

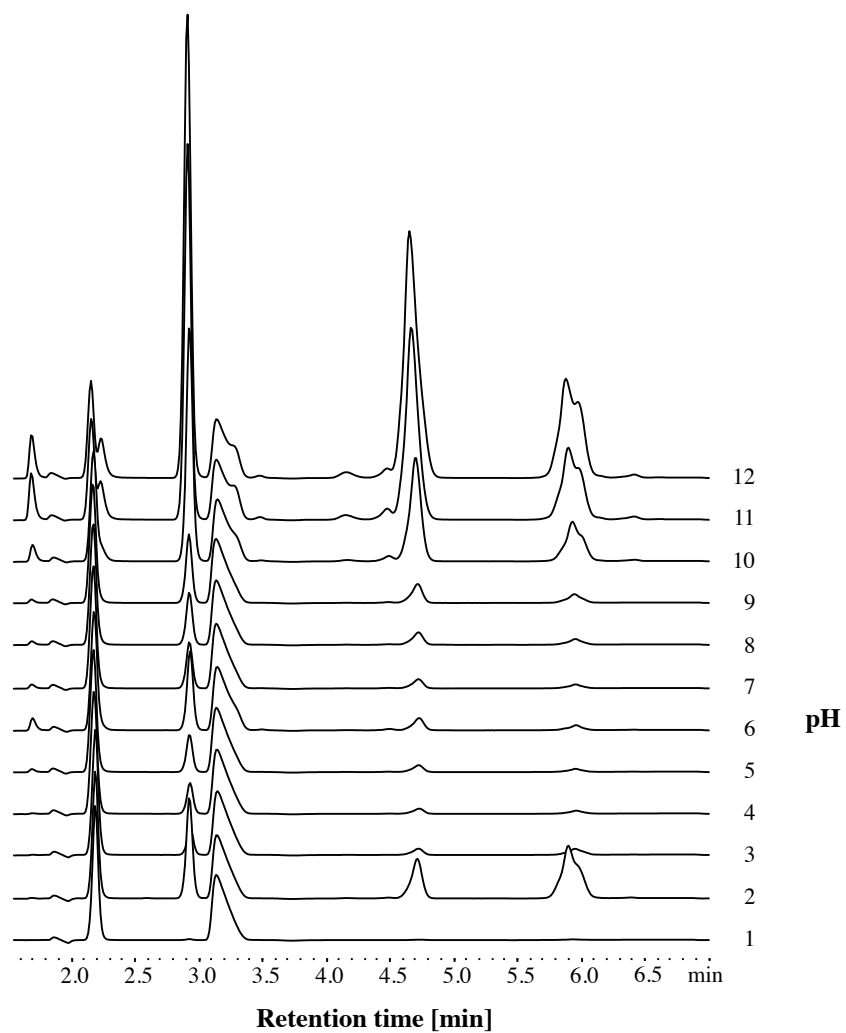


Fig. S27. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at 60°C as a function of pH.

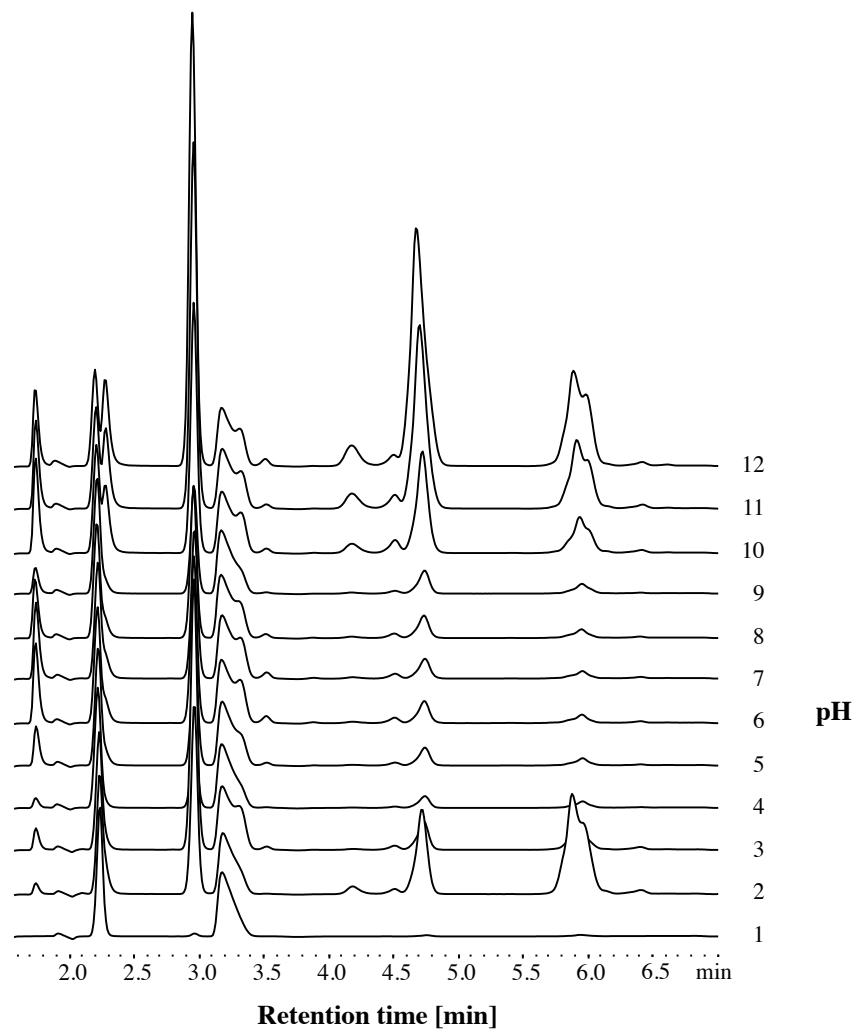


Fig. S28. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at 70°C as a function of pH.

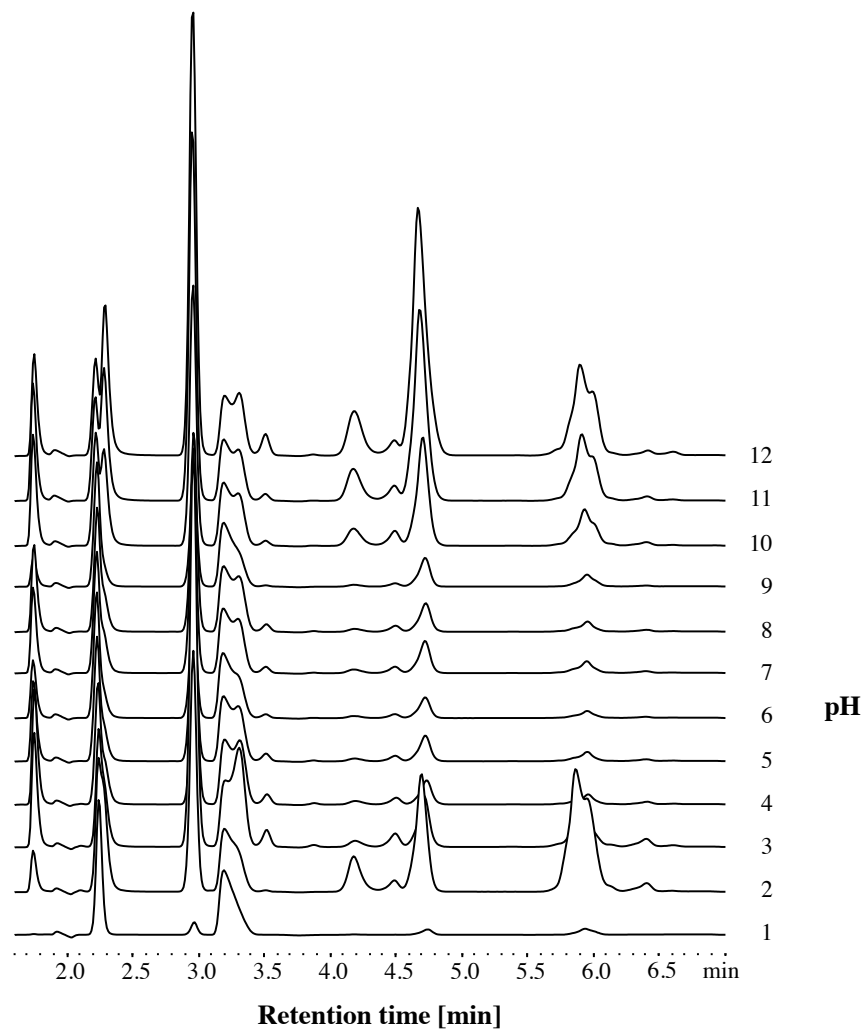


Fig. S29. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at 80°C as a function of pH.

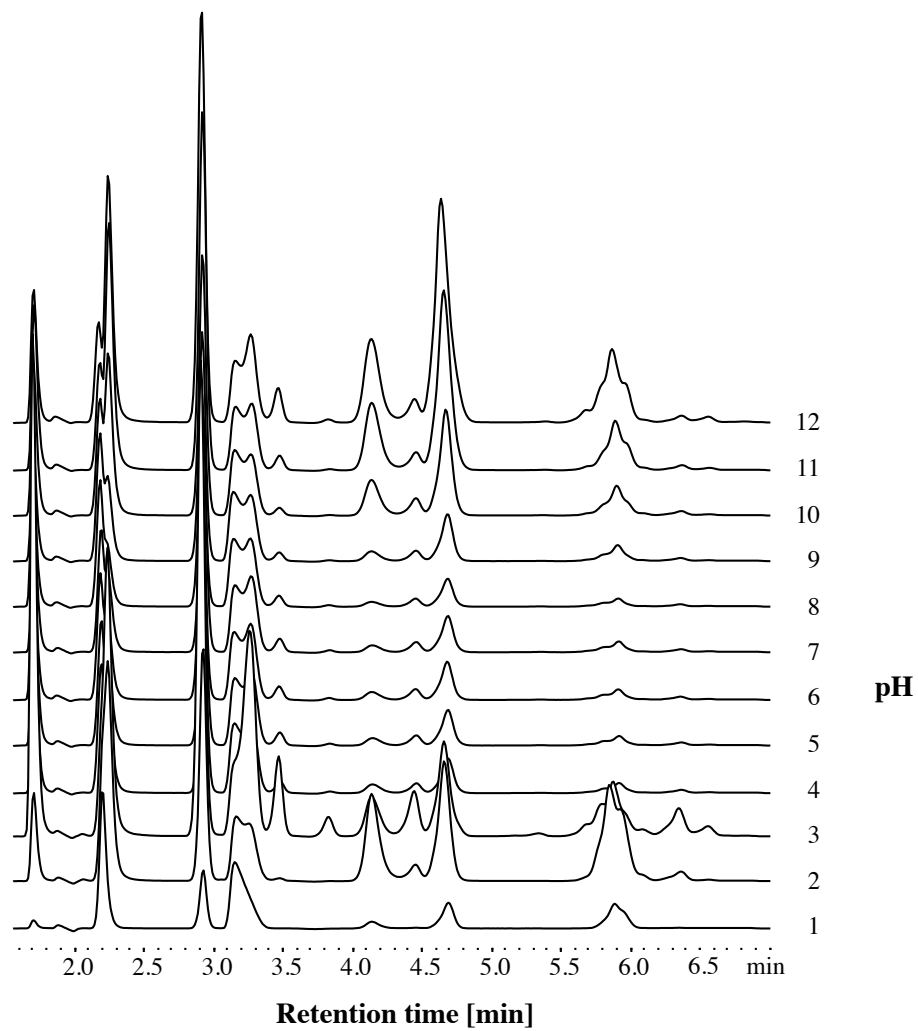


Fig. S30. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at 90°C as a function of pH.

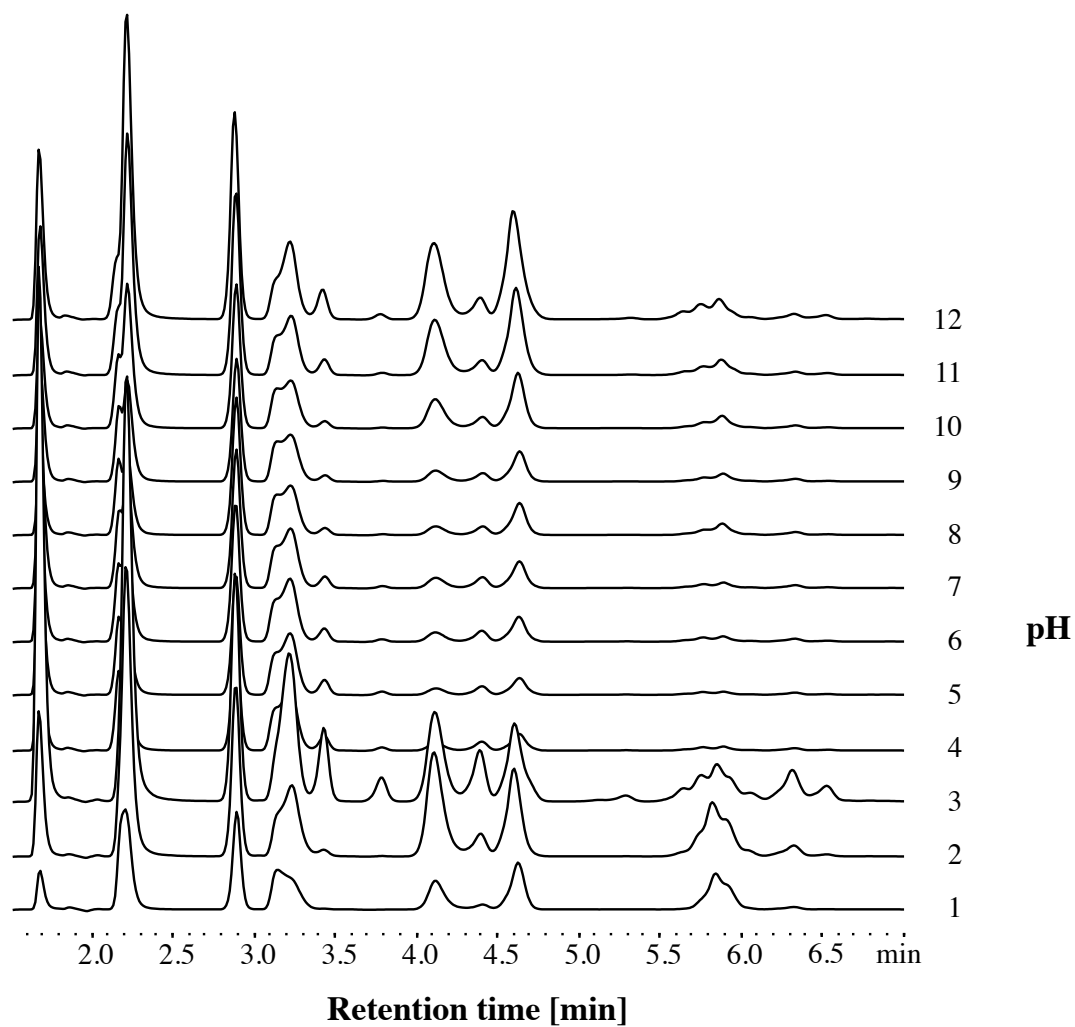


Fig. S31. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at 100°C as a function of pH.

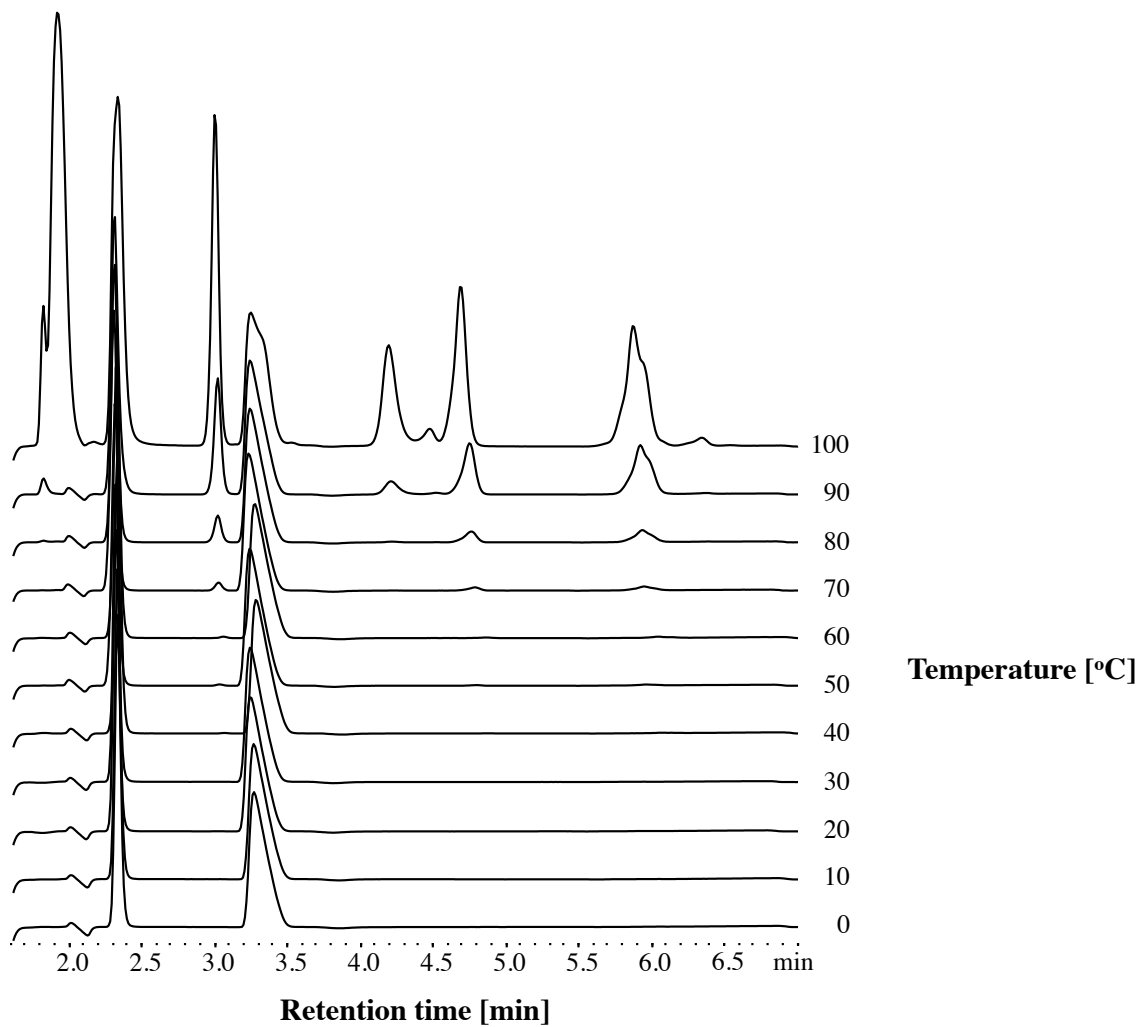


Fig. S32. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at pH 1 as a function of temperature.

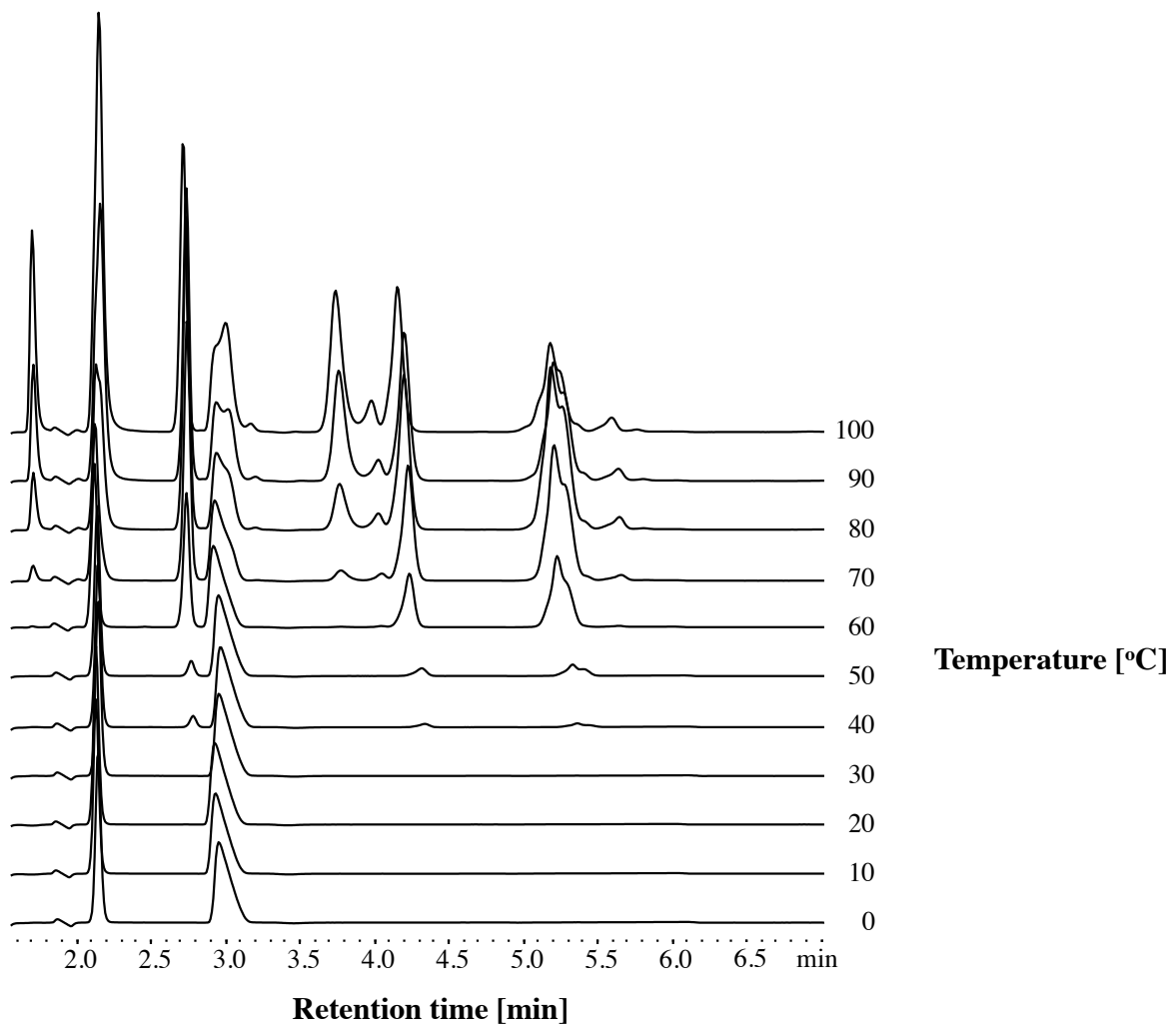


Fig. S33. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at pH 2 as a function of temperature.

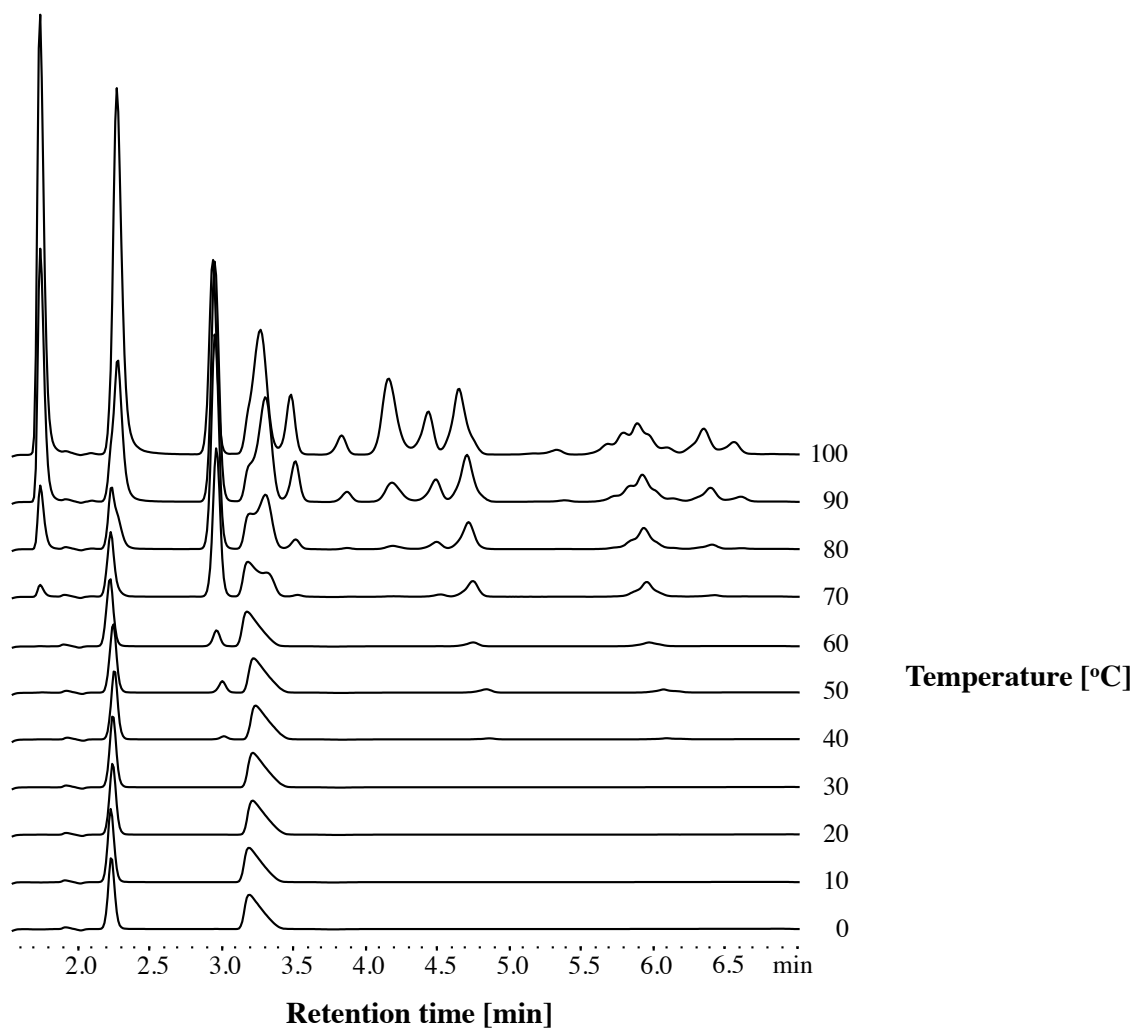


Fig. S34. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at pH 3 as a function of temperature.

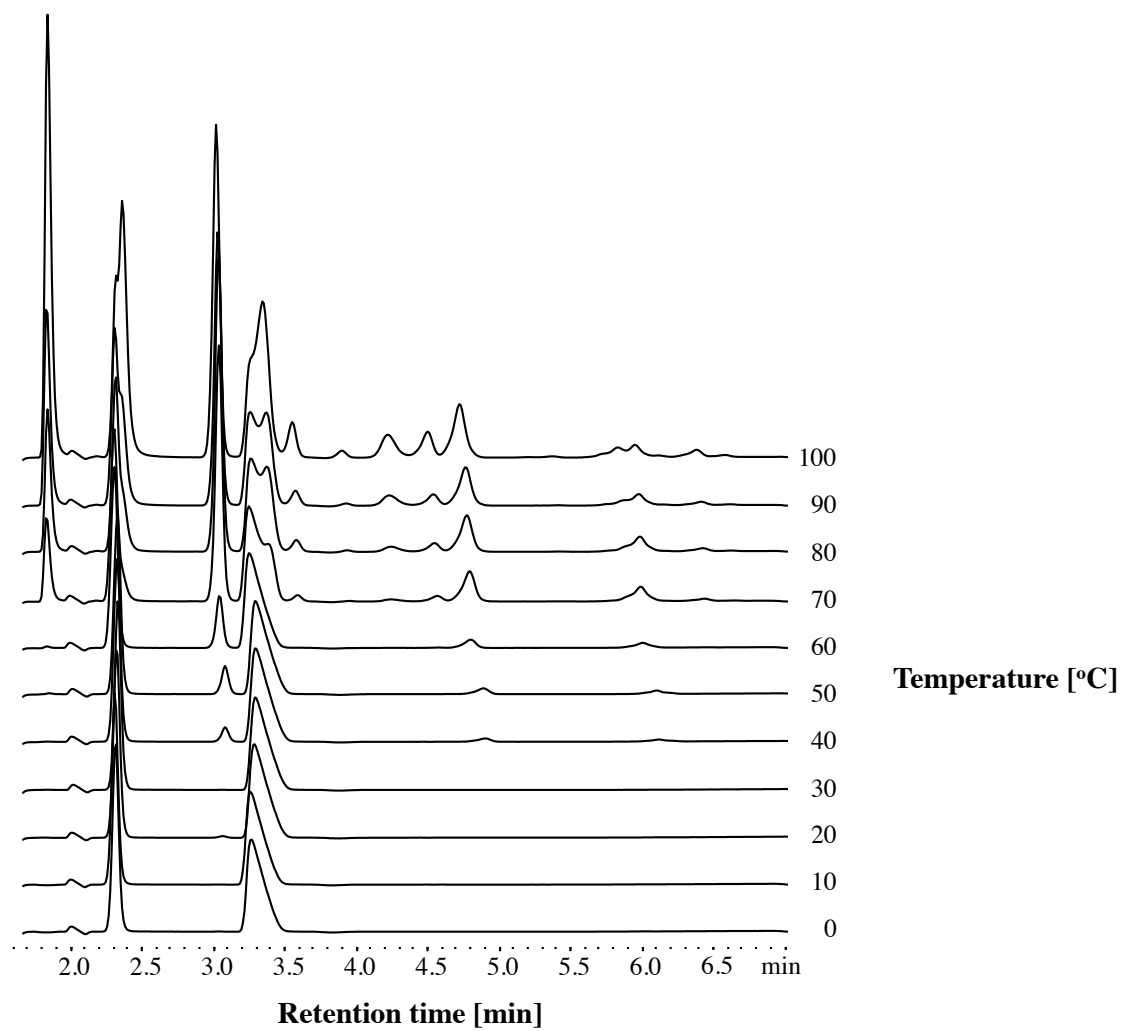


Fig. S35. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at pH 4 as a function of temperature.

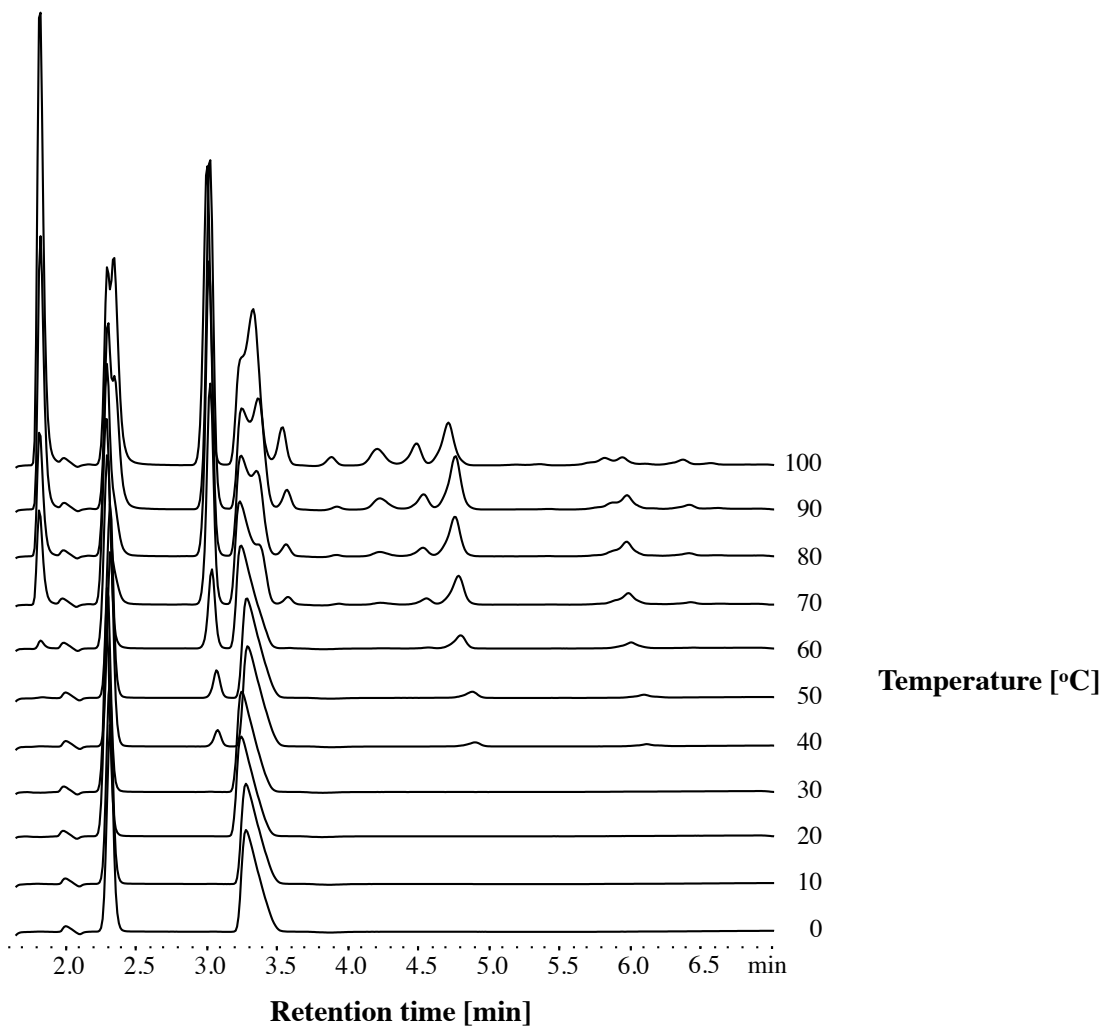


Fig. S36. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at pH 5 as a function of temperature.

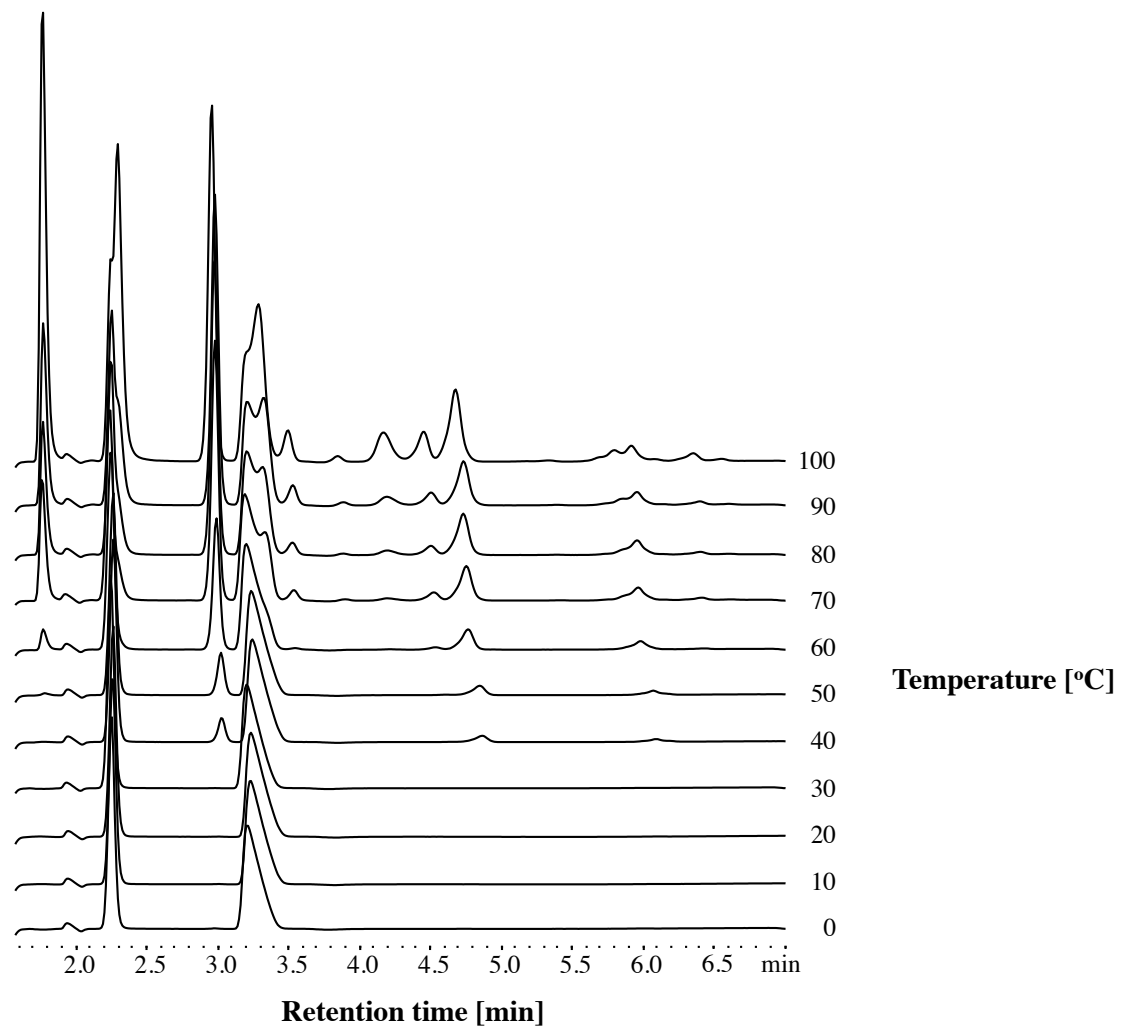


Fig. S37. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at pH 6 as a function of temperature.

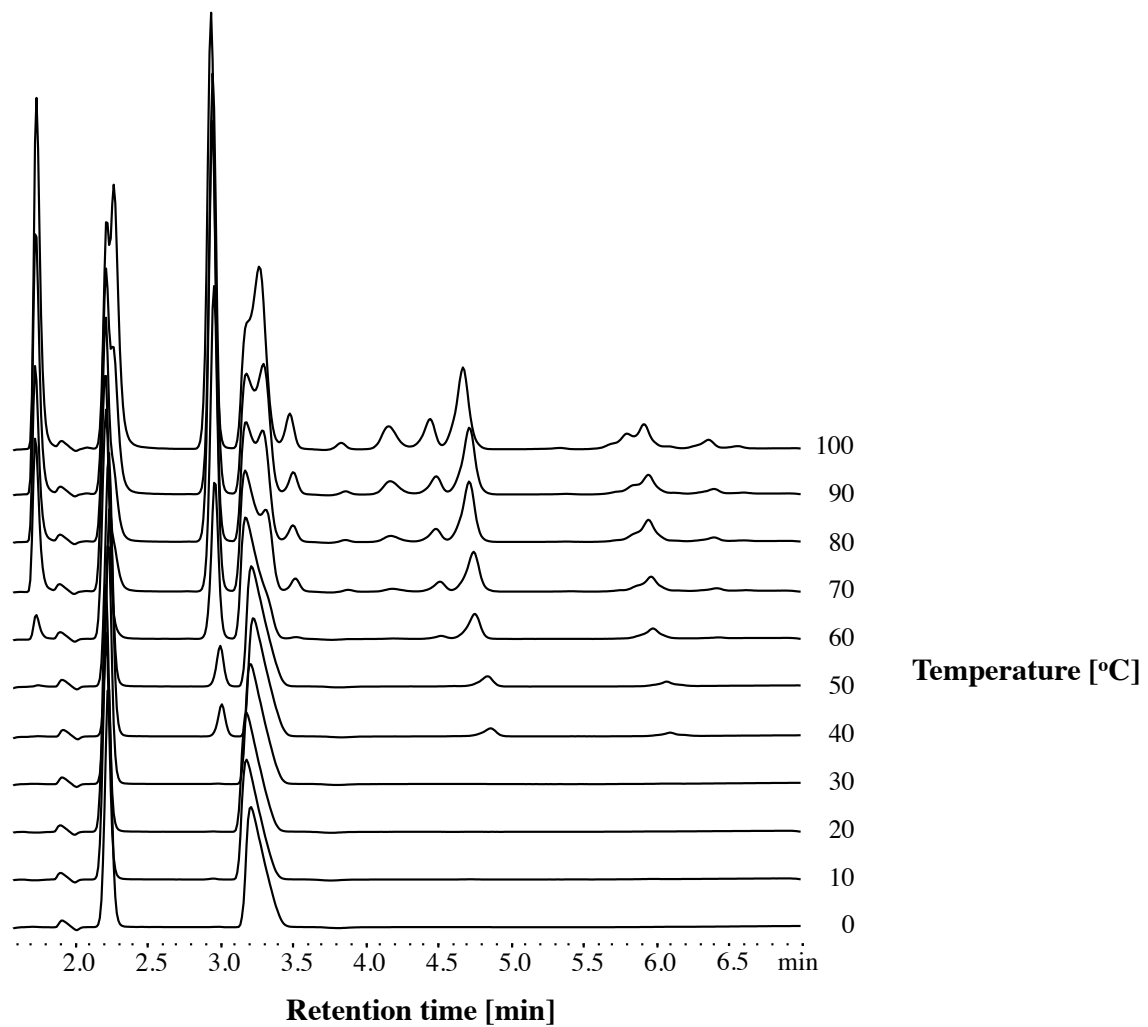


Fig. S38. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at pH 7 as a function of temperature.

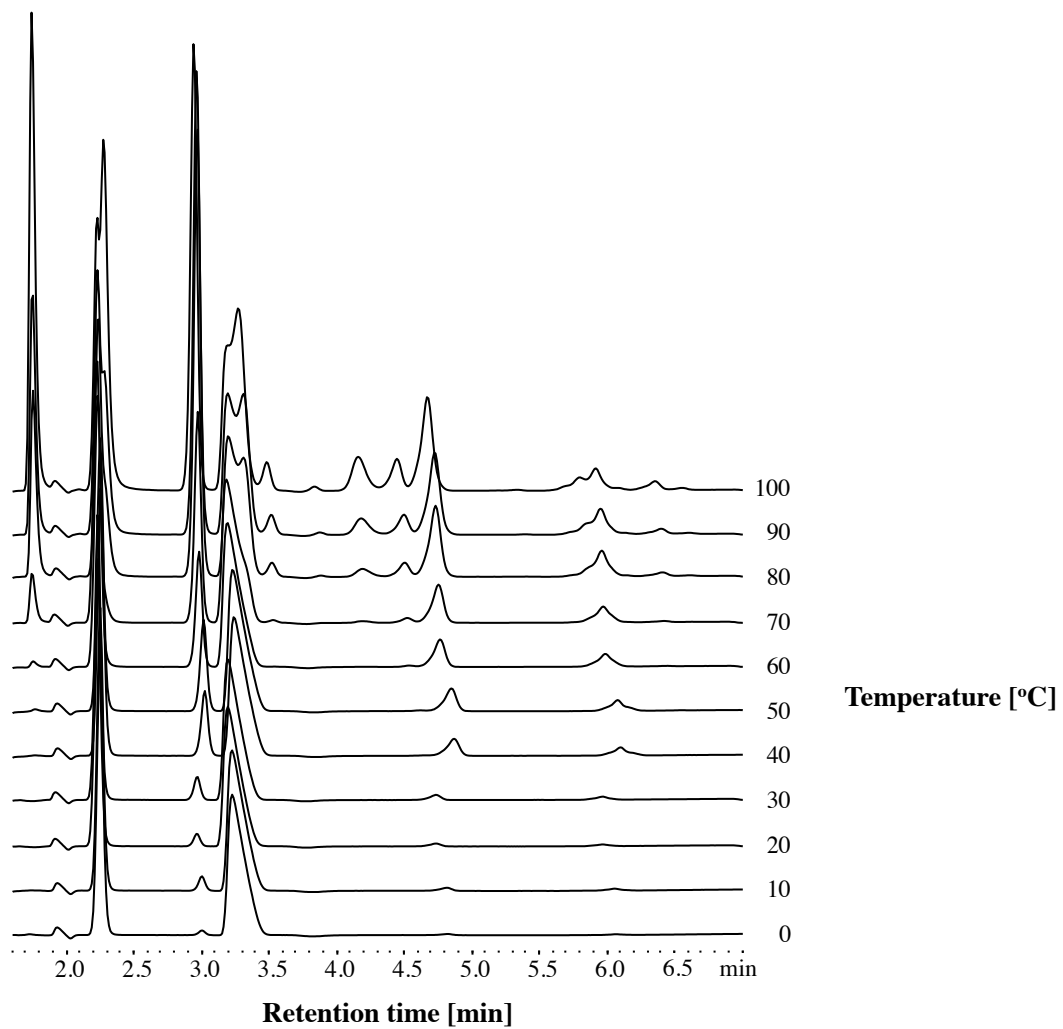


Fig. S39. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at pH 8 as a function of temperature.

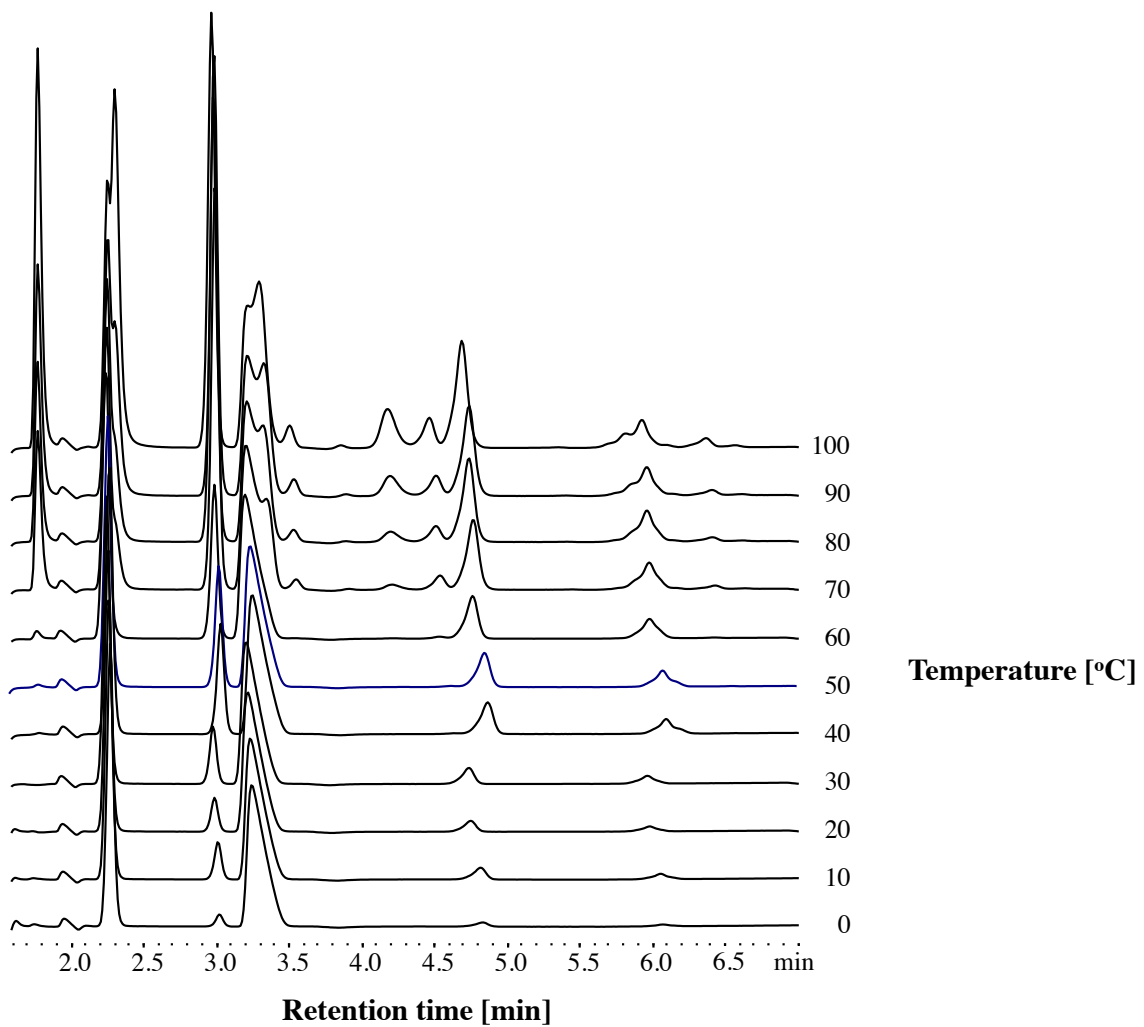


Fig. S40. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at pH 9 as a function of temperature.

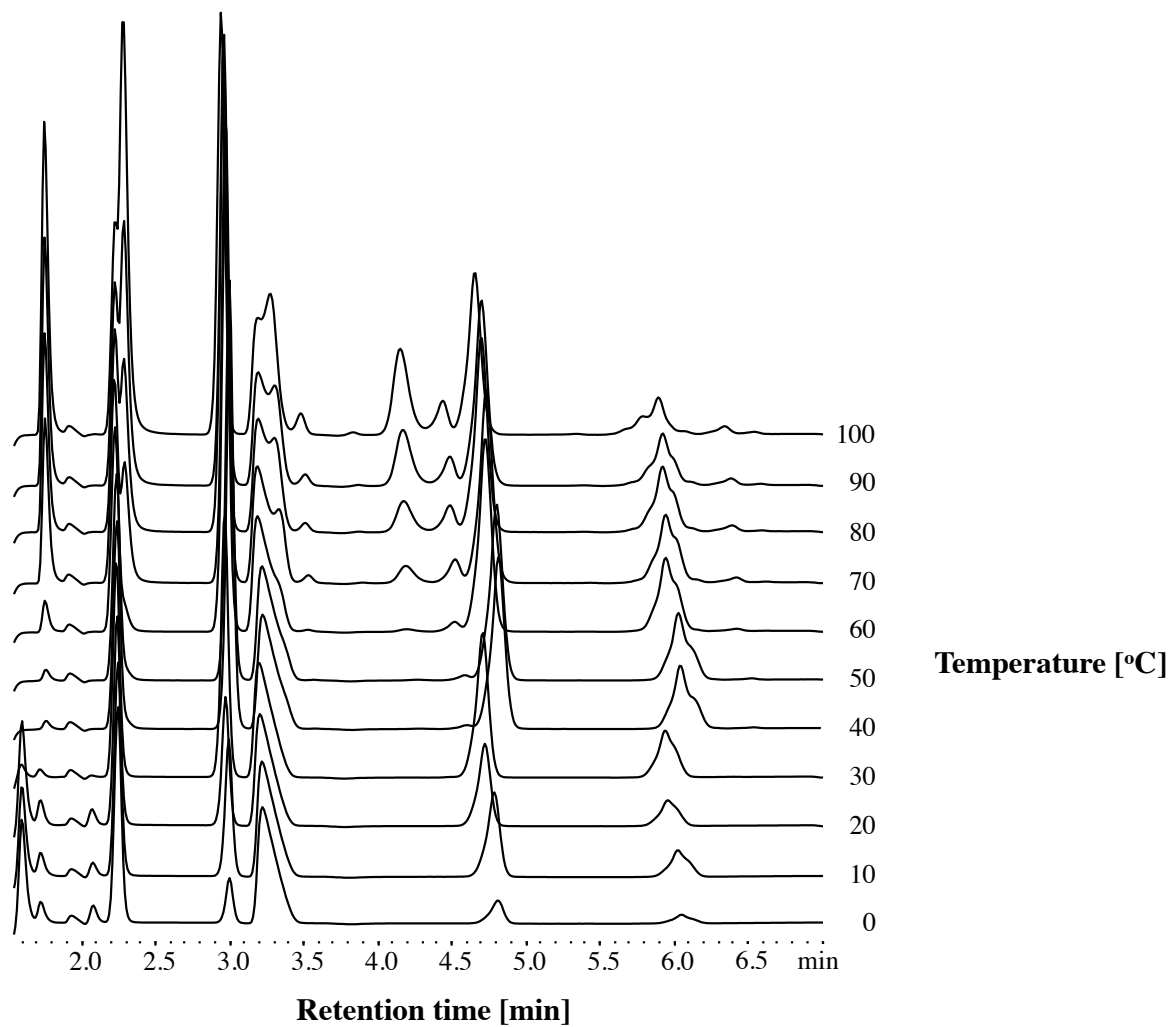


Fig. S41. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at pH 10 as a function of temperature.

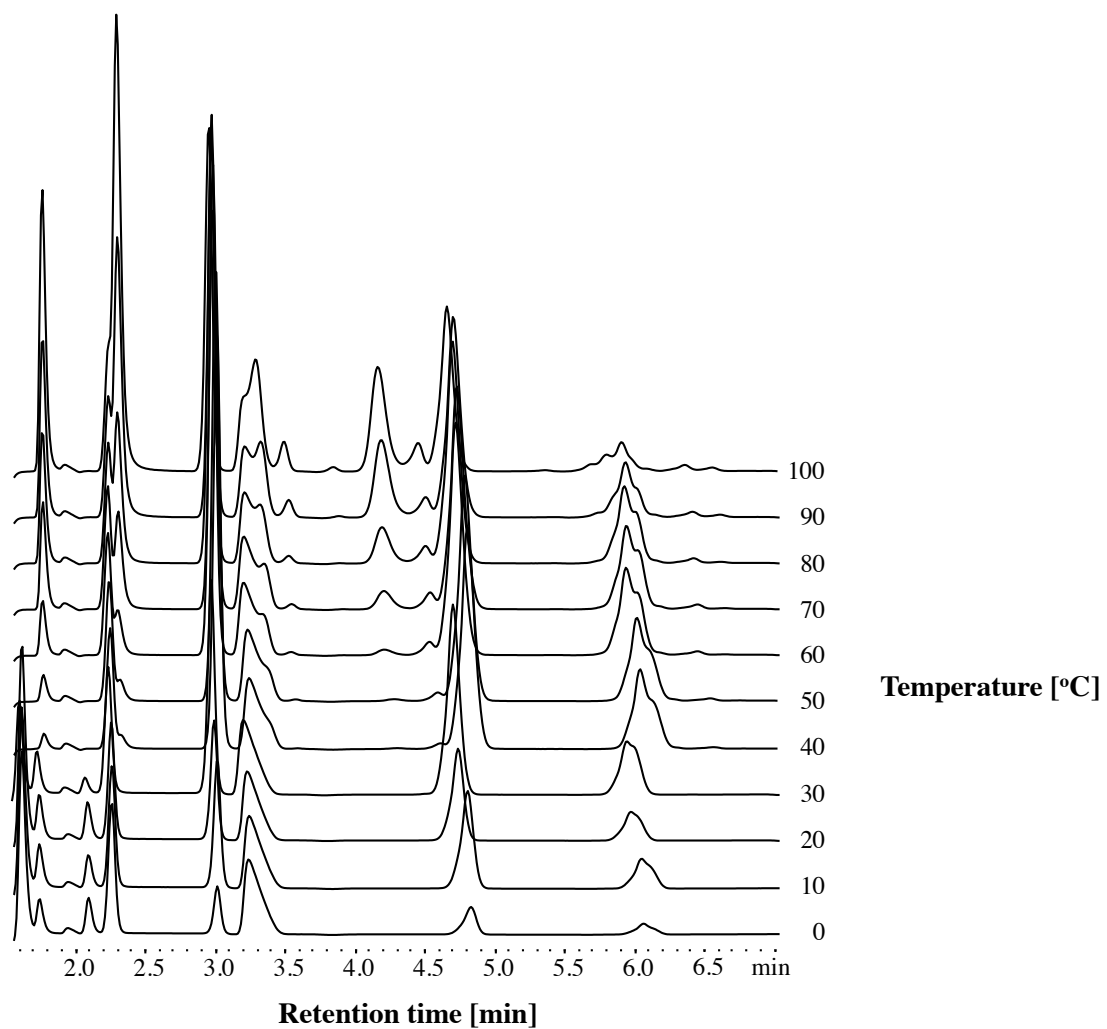


Fig. S42. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at pH 11 as a function of temperature.

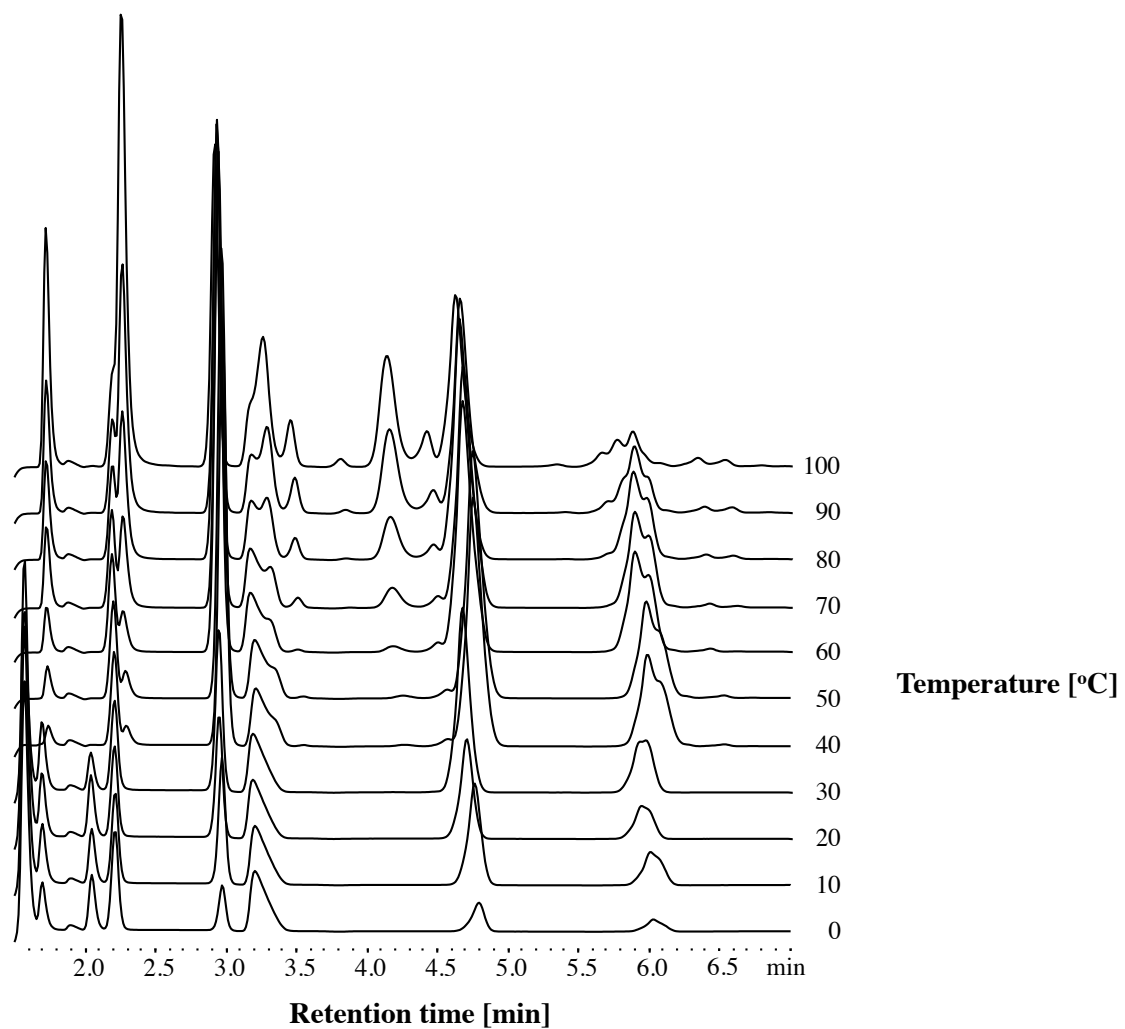


Fig. S43. Ion pairing HPLC chromatograms of an alanine and glycine condensation reaction in the presence of TP at pH 12 as a function of temperature.

C2 #1-145 RT: 0.07-9.94 AV: 27 NL: 9.46E3
F: FTMS + p MALDI Full ms [100.00-1000.00]

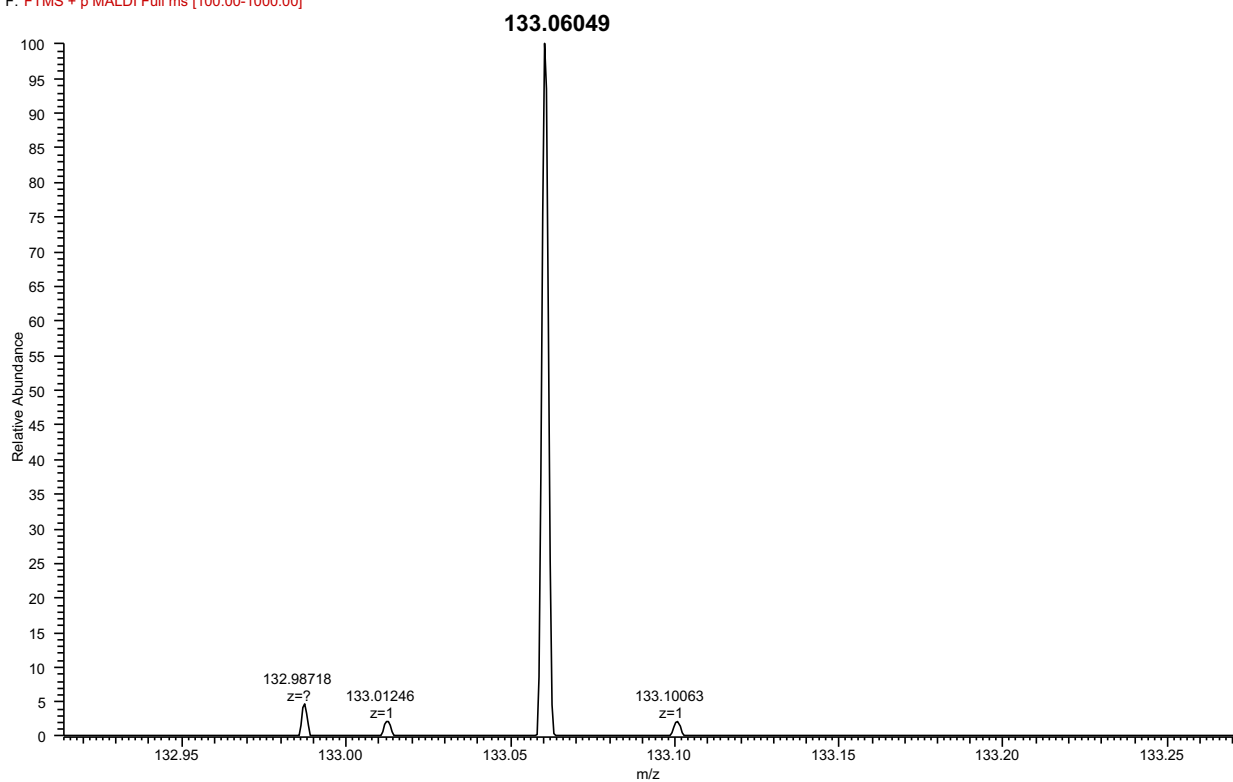


Fig. S44. MS spectra for 2G $[M+H]^+$ oligopeptide.

A+G,90oC, pH9#1-147 RT: 0.07-9.87 AV: 29 NL: 2.94E5
F: FTMS + p MALDI Full ms [100.00-1000.00]

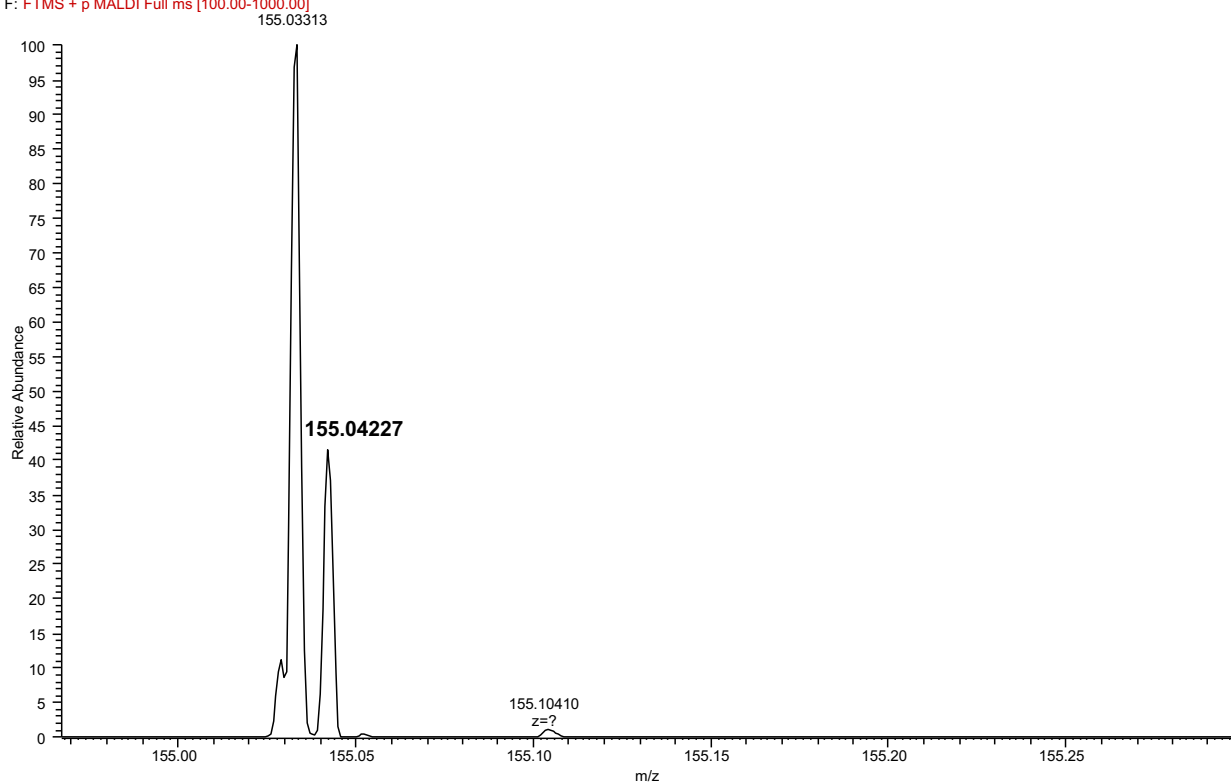


Fig. S45. MS spectra for 2G [M+Na]⁺ oligopeptide.

A+G,90oC, pH9 #1-147 RT: 0.07-9.87 AV: 29 NL: 1.08E4
F: FTMS + p MALDI Full ms [100.00-1000.00]

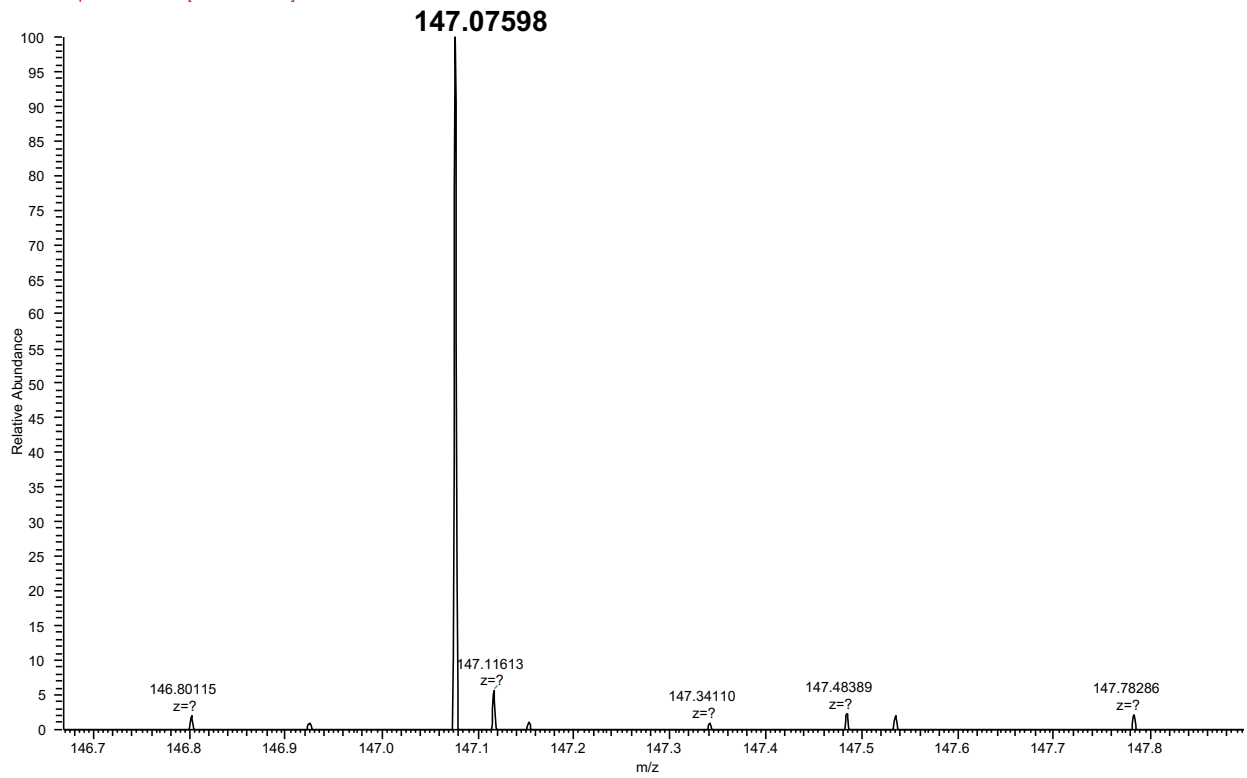


Fig. S46. MS spectra for AG $[M+H]^+$ oligopeptide.

A+G.90oC, pH 1-147 RT:0.07-9.87 AV: 29 NL:3.65E4
F: FTMS + p MALDI Full ms [100.00-1000.00]

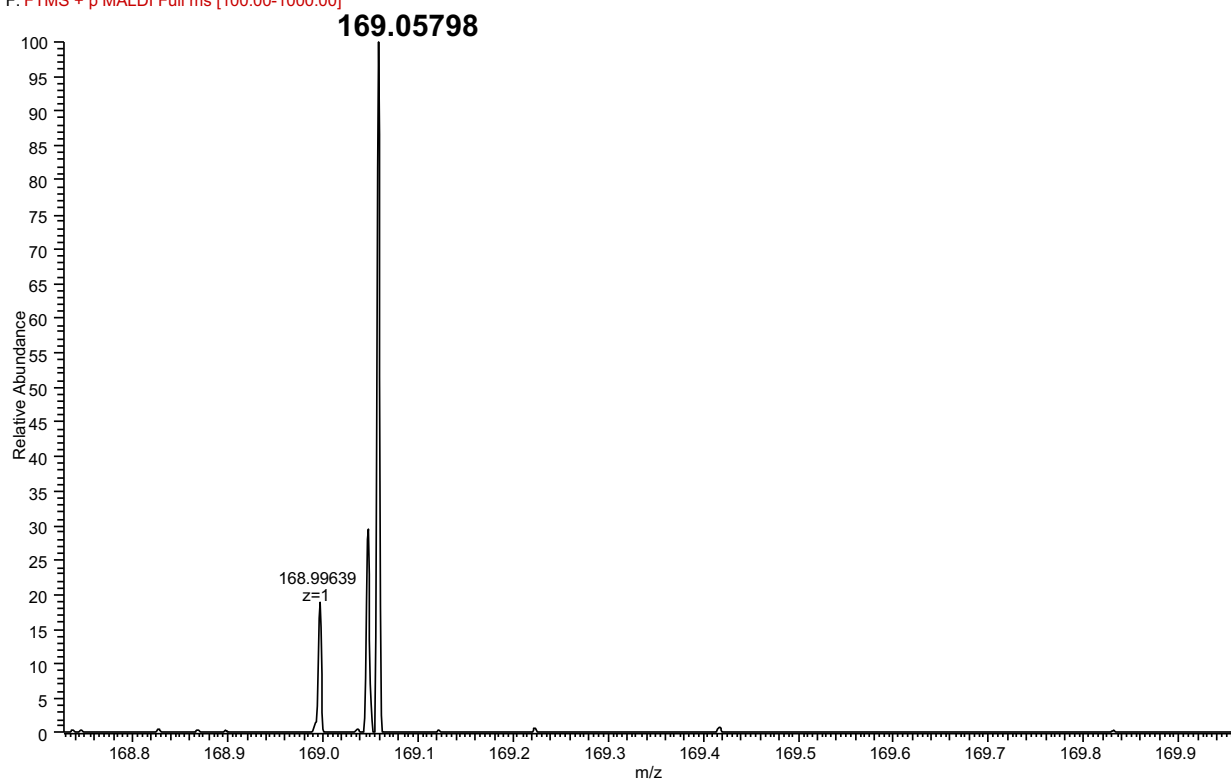


Fig. S47. MS spectra for AG $[M+Na]^+$ oligopeptide.

AGP.30oC, pH 11 #1-145 RT: 0.07-9.61 AV: 29 NL: 2.35E4
T: FTMS + p MALDI Full ms [100.00-1000.00]

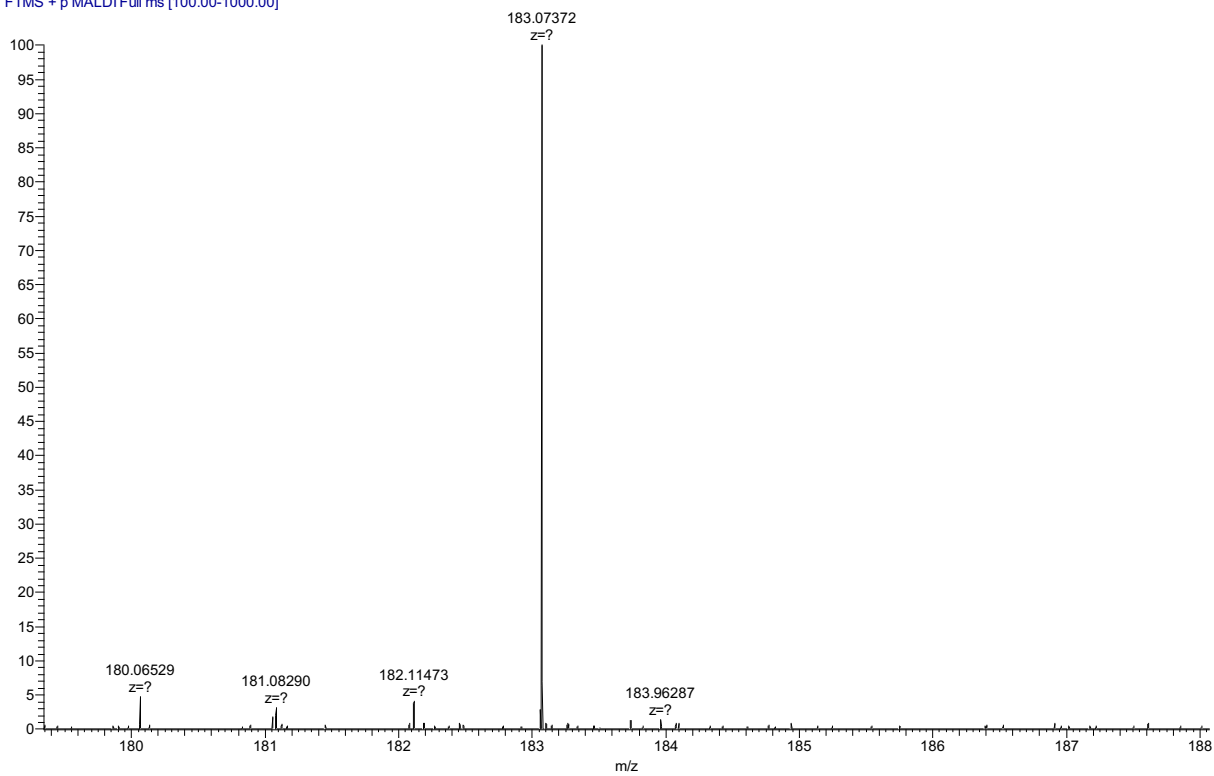


Fig. S48. MS spectra for 2A $[M+Na]^+$ oligopeptide.

A+G,90oC, pH9#1-147 RT: 0.07-9.87 AV: 29 NL: 1.11E4
F: FTMS + p MALDI Full ms [100.00-1000.00]

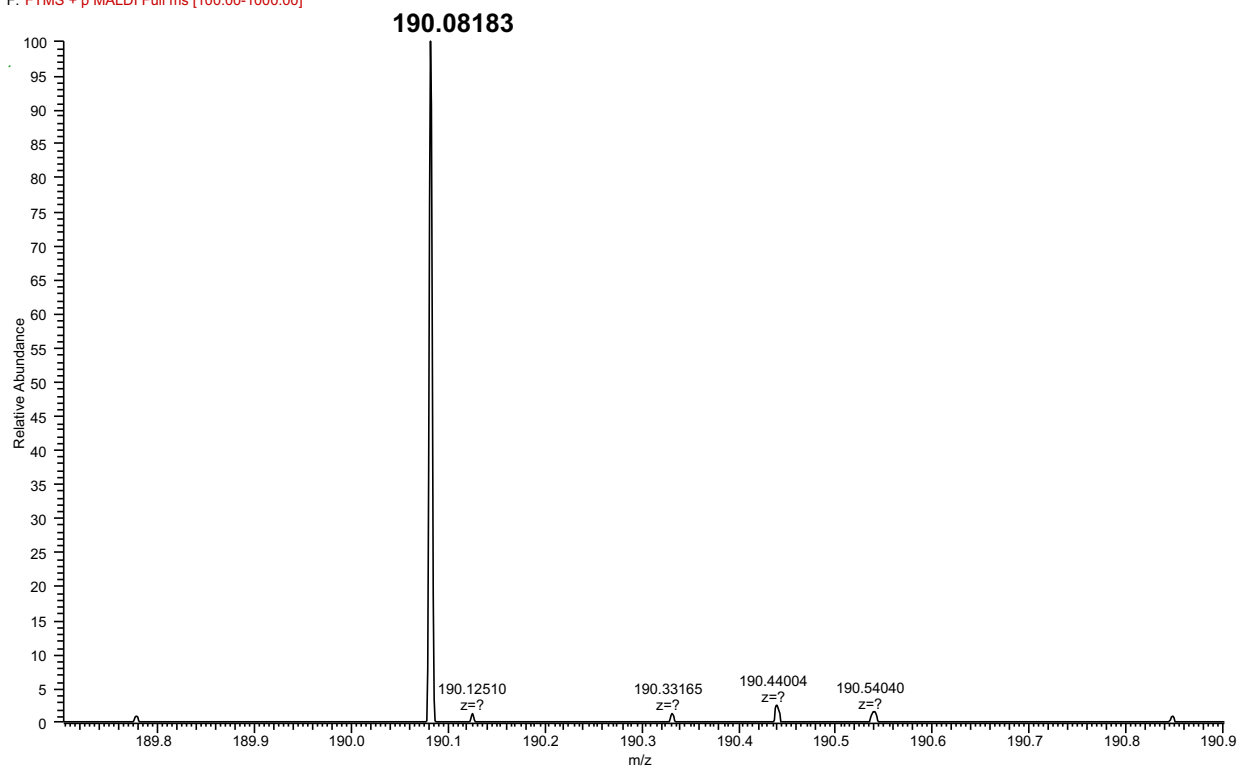


Fig. S49. MS spectra for 3G [M+H]⁺ oligopeptide.

C2 #1-145 RT: 0.07-9.94 AV: 27 NL: 7.91E4
T: FTMS + p MALDI Full ms [100.00-1000.00]

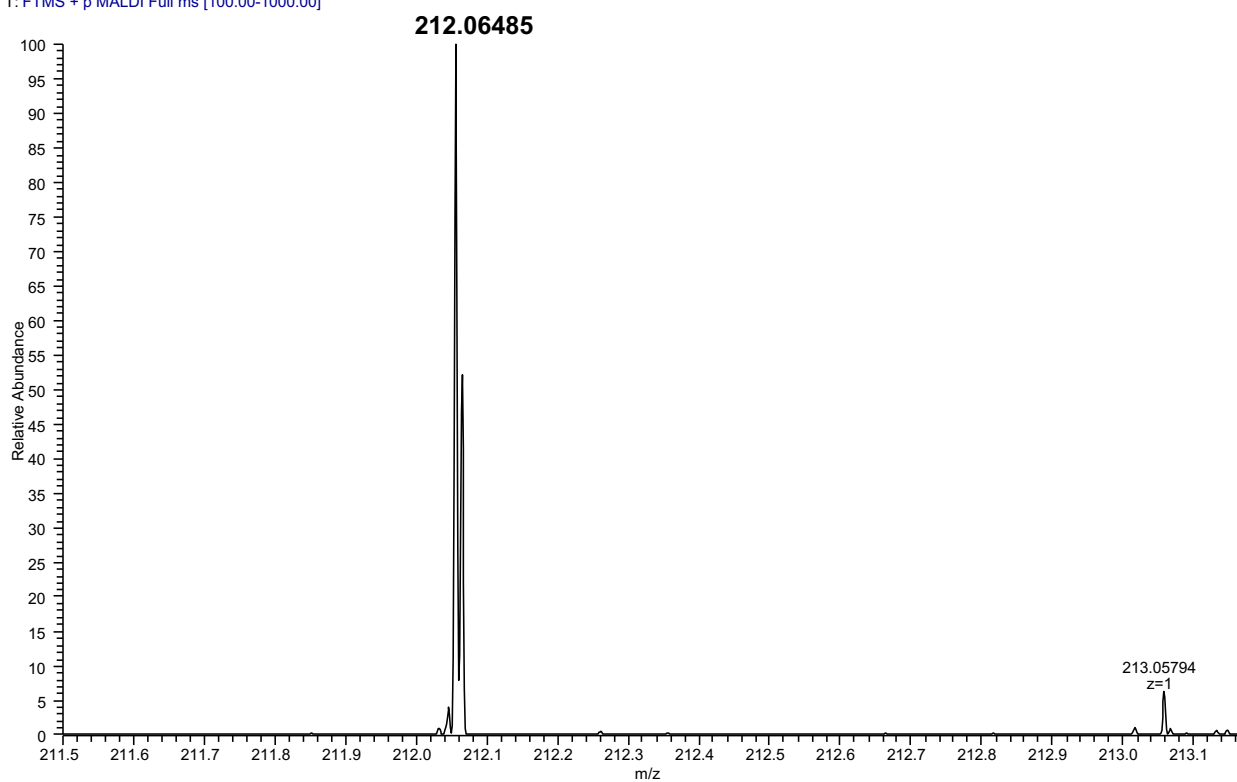


Fig. S50. MS spectra for 3G $[M+Na]^+$ oligopeptide.

A+G,100oC, pH#1-146 RT:0.07-9.95 AV: 32 NL: 4.82E3
T: FTMS + p MALDI Full ms [100.00-1000.00]

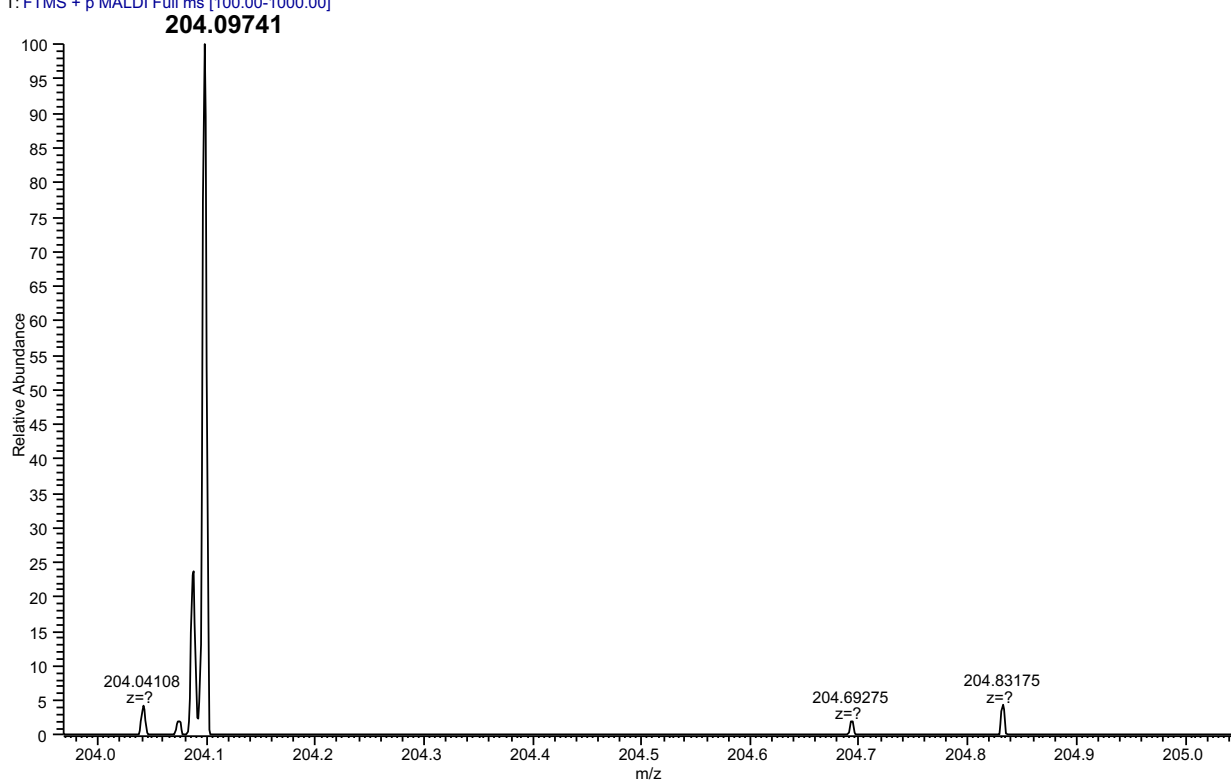


Fig. S51. MS spectra for 2GA $[M+H]^+$ oligopeptide.

A+G, 100oC, pH9 #1-146 RT: 0.07-9.95 AV: 32 NL: 2.31E5
T: FTMS + p MALDI Full ms [100.00-1000.00]

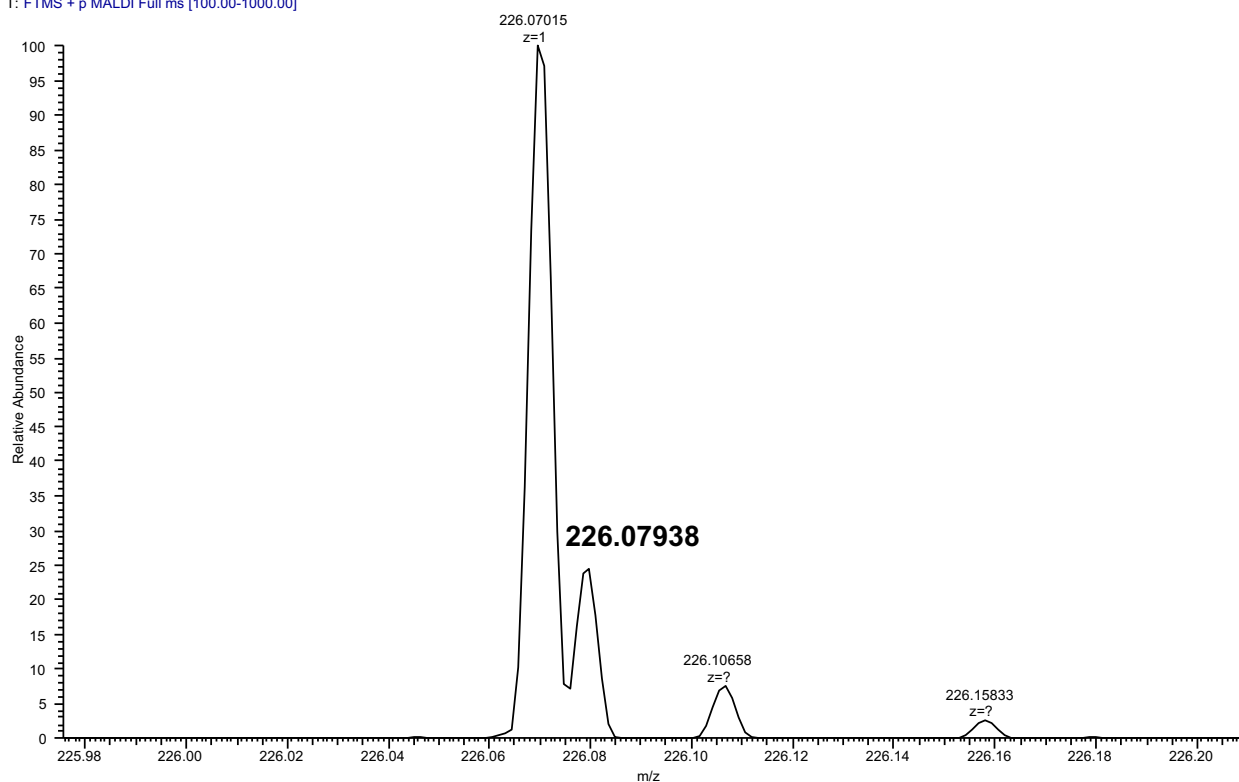


Fig. S52. MS spectra for 2GA $[M+Na]^+$ oligopeptide.

A+G.90oC, pH9 #1-147 RT: 0.07-9.87 AV: 29 NL: 2.17E4
F: FTMS + p MALDI Full ms [100.00-1000.00]

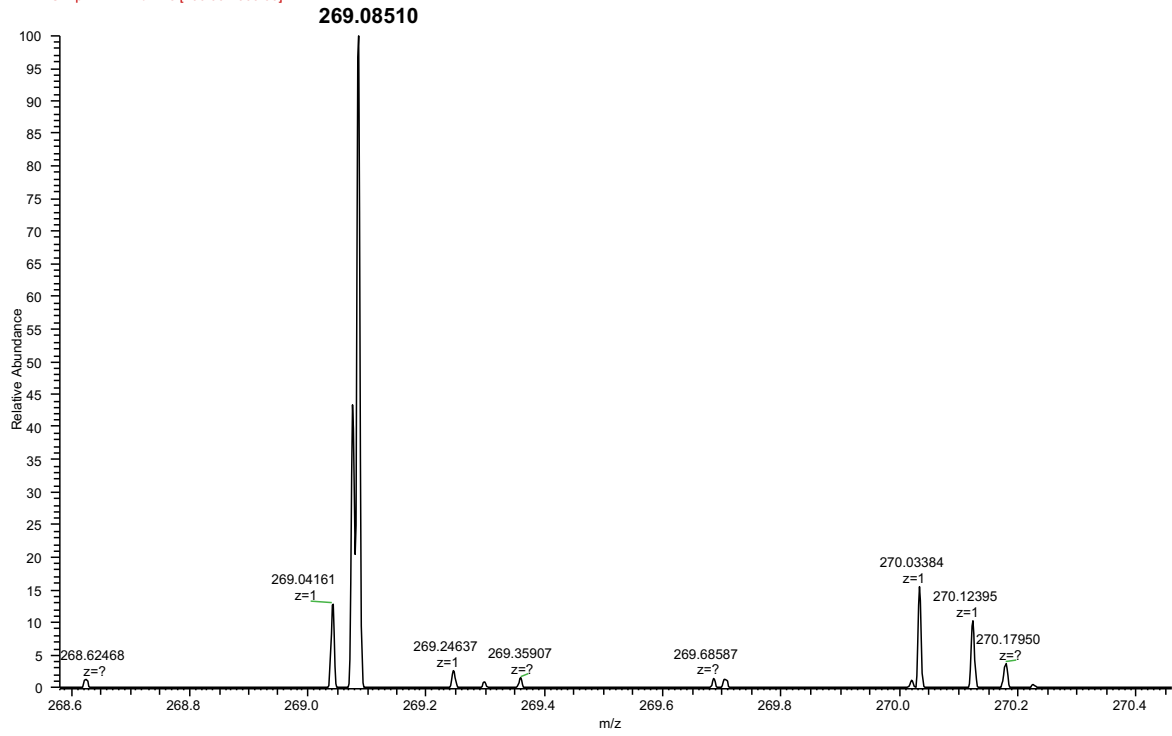


Fig. S53. MS spectra for 4G $[M+Na]^+$ oligopeptide.

C6 #140 RT: 9.57 AV: 1 NL: 6.62E5
T: FTMS + p MALDI d Full ms2 212.05@hcd35.00 [75.00-225.00]

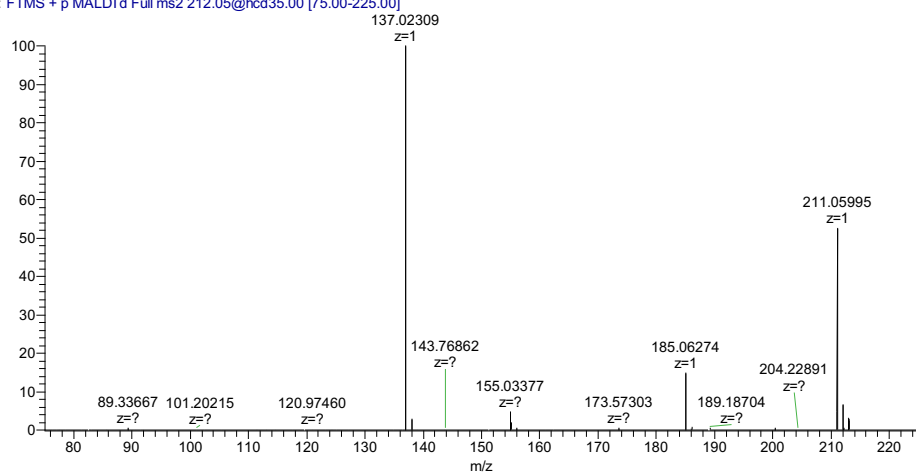


Fig. S54. MS/MS spectra for 3G $[M+Na]^+$ oligopeptide.

C6 #134 RT: 9.15 AV: 1 NL: 6.93E4
T: FTMS + p MALDI d Full ms2 226.07@hcd35.00 [75.00-240.00]

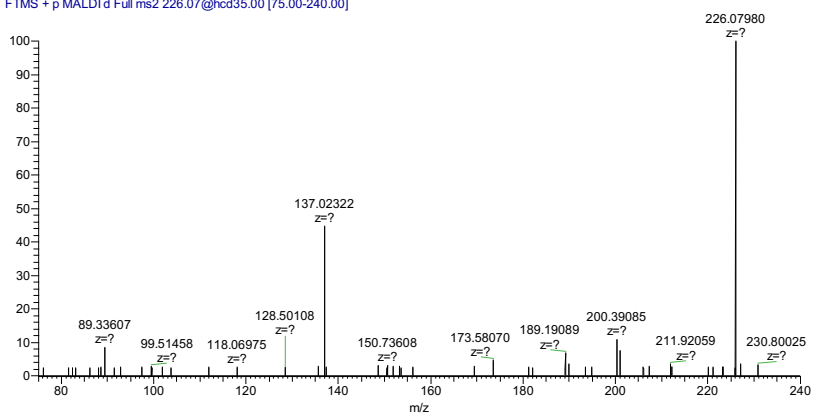


Fig. S55. MS/MS spectra for GGA $[M+Na]^+$ oligopeptide.

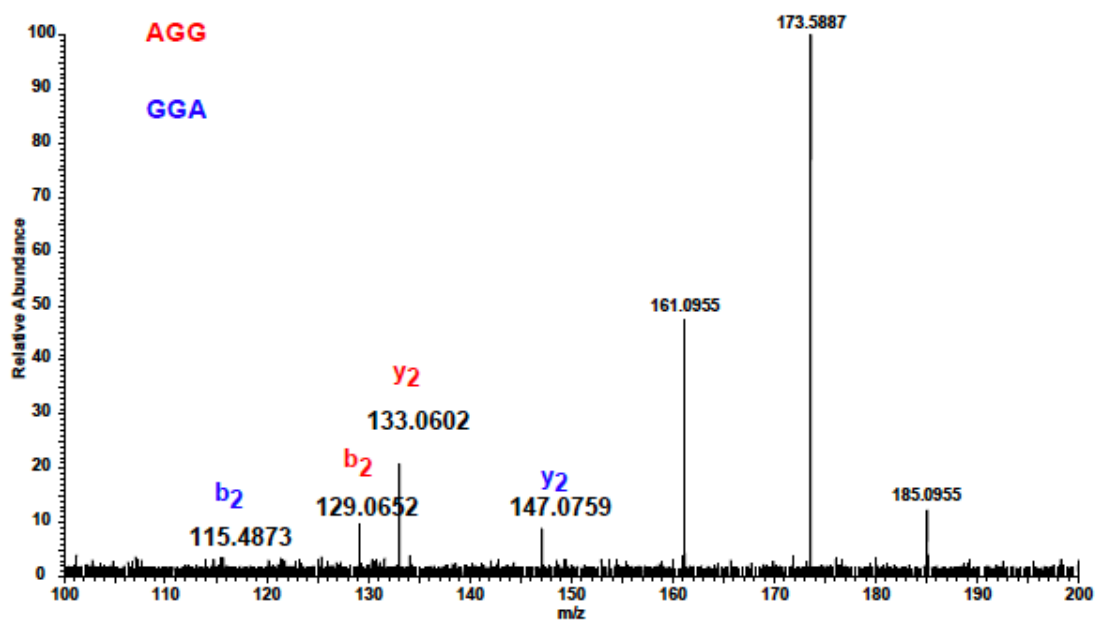


Fig. S56. MS/MS spectra for AGG and GGA [M+H]⁺ oligopeptide mix.