LPSC-2020 Abstract #1782

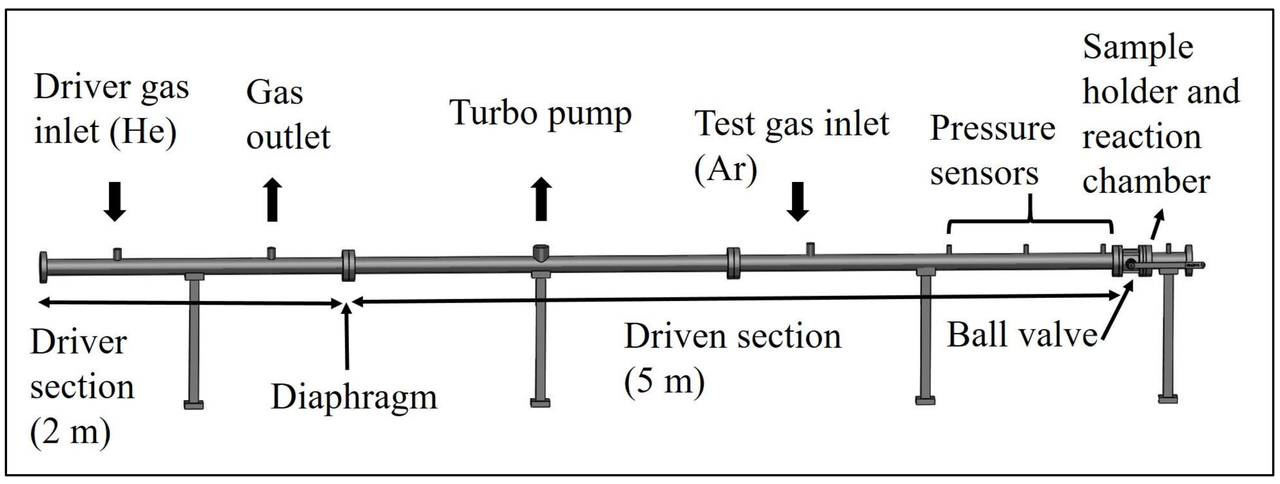
Shock Synthesis of Complex Macroscale Structure in Impacting Mixture of Amino Acids and Nucleobases: Pathways Towards Complexity

V S Surendra[1]*, V Jayaram[2], S Karthik[1], S Vijayan[1], V Chandrasekaran[3], R Thombre[4], T Vijay[5], B N Raja Sekhar[6], A Bhardwaj[1], G Jagadeesh[2], K P J Reddy[2], N J Mason[7], B Sivaraman[1]*
[1]PRL Ahmedabad, India, [2] IISC Bangalore, India, [3]VIT Vellore, India, [4]Modern College of Arts and Science, Pune, India, [5]IIT Gandhinagar, Gandhinagar, [6]BARC, Mumbai, India, [7]University of Kent, United Kingdom
*surendra@prl.res.in, bhala@prl.res.in

Objective

The building blocks of life, such as amino acids and nucleobases, are very well known to have been synthesized, starting from simple molecules containing hydrogen, carbon, oxygen, and nitrogen, in extreme conditions triggered by various processing. Previous reports suggest that the shock processing of simple molecules can lead to the synthesis of building blocks of life, such as amino acids too [1,2]. However, the fate and role of amino acids/nucleobases when they are subjected to similar processes largely remains unexplored [3]. Here, we aim to experimentally verify the shock processing of amino acids and nucleobases in a controlled laboratory environment, utilizing a shock tube. The results suggests that they polymerize to complex macroscale structure when subjected to shock within 2 ms timescale over post shock temperature of up to 8000K.

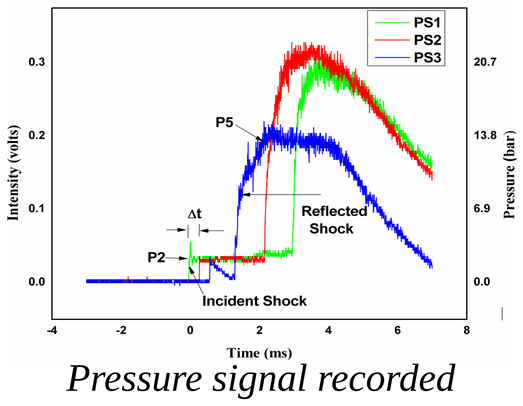
Shock processing: Experimental set-up



Schematic diagram of shock tube to simulate impact-shock condition in laboratory

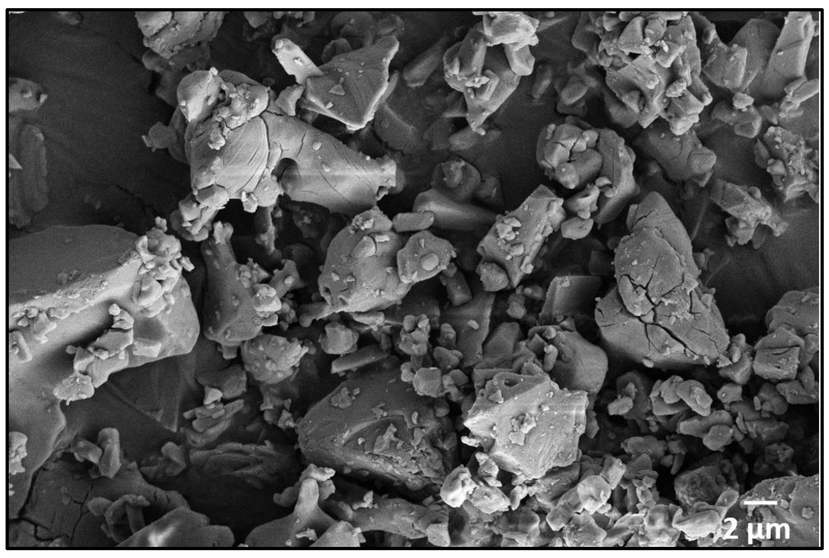
Diaphragm of different thickness and groove depth	Bursting Pressure (bar)	Mach Number	Approximate Reflected Shock Temperature (K)
2 mm ¼ th Al	56	5.95	8088
2 mm ⅓ rd Al	46.5	4.67	5024
1.5 mm ⅓ rd Al	32.1	3.88	3525

Shock tube parameters

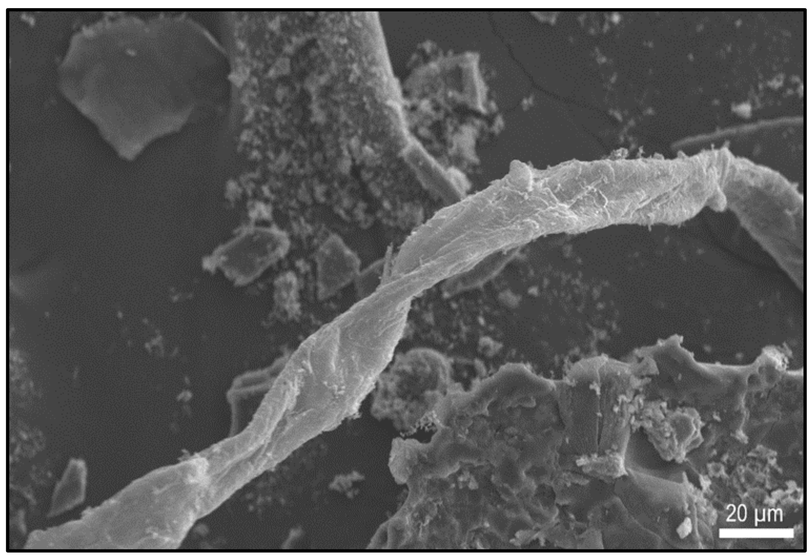


Pressure signal recorded form oscilloscope to calculate Mach number and shock temperature

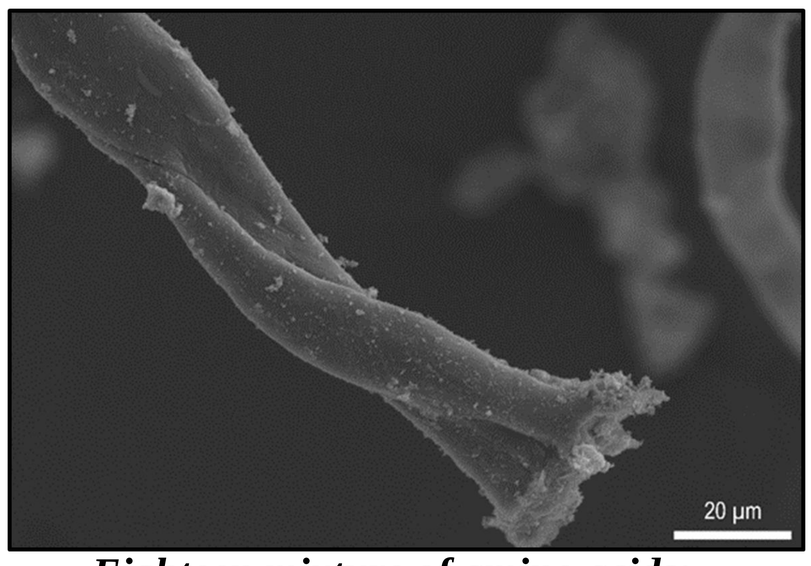
SEM micrographs: Complex macroscale structures



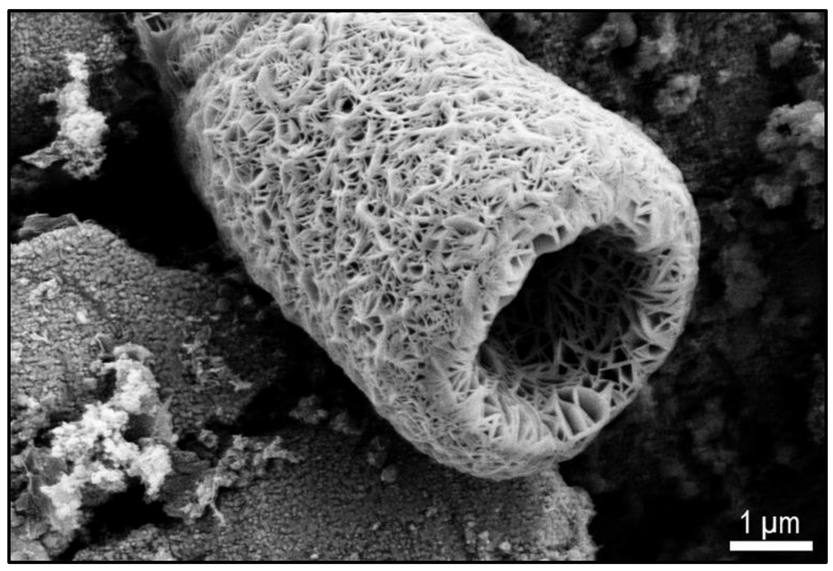
SEM micrograph of unprocessed amino acid sample



Glycine after shock processing: *Fine twisted thread feature*

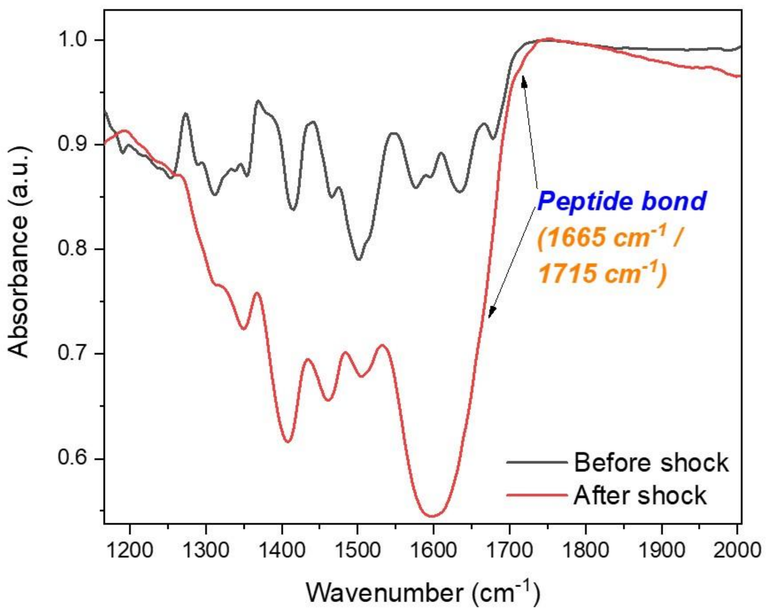


Eighteen mixture of amino acids: *The twisting and branching structure*



Four amino acids (Lysine, Aspartic acid, Arginine, Glutamic acid): *Formation of porous cylindrical feature after shock processing*

IR spectra of shock processed residue



1665 cm^{-1}/ 1715 cm^{-1} corresponding to peptide bond observed in the shocked sample of lysine, aspartic acid, arginine, glutamic acid mixture

Initial implications and future work

The tendency of amino acid towards the formation of complex macroscale structure provides evidence for the evolution of the building blocks of life under impact shock condition. Molecules such as amino acids/nucleobases are considered as important precursors of life. However, natural biological structures containing proteins or polypeptides or lipids, etc., which has a direct link with sustained biological evolution is still missing. In this perspective, our results have significant insights. These structures also provide a possible explanation for organized structures seen in meteorites [4]. Further investigations are being conducted, which will take us one step further towards our understanding of the origins of life and will help to bridge the gap between molecules and life.

References

[1] Bar-Nun, et al. (1970) *Science*, *168*, 470-47. [2] Goldman, N. et al. (2010) *Nature Chemistry*, *827*, 949-954. [3] Sugahara and Mimura (2014), *Geochemical Journal*, *48*, 51-62. [4] Mamikunian, G. et al. (1963) *Nature*, *197*, 1245-1248.