Final Technical Report

Cooperative Agreement NCC2-948

SHOCK MODIFICATIONS OF ORGANIC COMPOUNDS IN CARBONACEOUS CHONDRITE PARENT BODIES

June 5, 1998

by

George W. Cooper
Principal Investigator
SETI Institute

Background

Impacts among asteroidal objects would have altered or destroyed pre-existing organic matter in both targets and projectiles to a greater or lesser degree depending upon impact velocities. To begin filling a knowledge gap on the shock metamorphism of organic compounds, we are studying the effects of shock impacts on selected classes of organic compounds utilizing laboratory shock facilities. Our approach is to subject mixtures of organic compounds, embedded in the matrix of the Murchison meteorite, to simulated hypervelocity impacts by firing them into targets at various pressures. The mixtures are then analyzed to determine the amount of each compound that survives as well as to determine if new compounds are being synthesized. The initial compounds added to the matrix (with the exception of thiosulfate - see below) are shown in Table 1. The sulfonic acids were chosen in part because they are relatively abundant in Murchison, relatively stable, and because they and the phosphonic acids are the first well-characterized homologous series of organic sulfur and phosphorus compounds identified in an extraterrestrial material.

Experimental procedures were more fully described in the original proposal. A known amount of each compound was added to a sample of powdered Murchison meteorite, shocked at various pressures, extracted with water, and quantified by ion chromatography. The shock experiment was done under the guidance of F. Horz in the Experimental Impact Laboratory of the Johnson Space Center, Houston. A 20 mm gun, with its barrel extending into a vacuum chamber (10^{-2} torr), was used to launch the projectile containing the sample at ~1.6 km/sec (3,600 mi/hr) into the target material. Maximum pressure of impact depend on target/projectile materials. The target was sufficiently thin to assure minimum pressure decay over the total sample thickness.

Results and current work

Table 1 and Figure 1 show the percent of each compound surviving versus pressure. In the course of analysis a new compound, thiosulfate, was identified. Thiosulfate (indigenous to the meteorite) was seen as an unidentified peak on previous ion chromatograms of Murchison and its survival versus pressure was also measured. The results show that a portion of all but two of the compounds, ipsa and npsa, survive even at 42.9 GPa. We are in the process of analyzing a set of samples just recently shocked. These samples consist of some of the same compounds used in the above experiment (for confirmation of results) as well as additional compounds. These include amino acids and polyaromatic hydrocarbons.

Figure 1

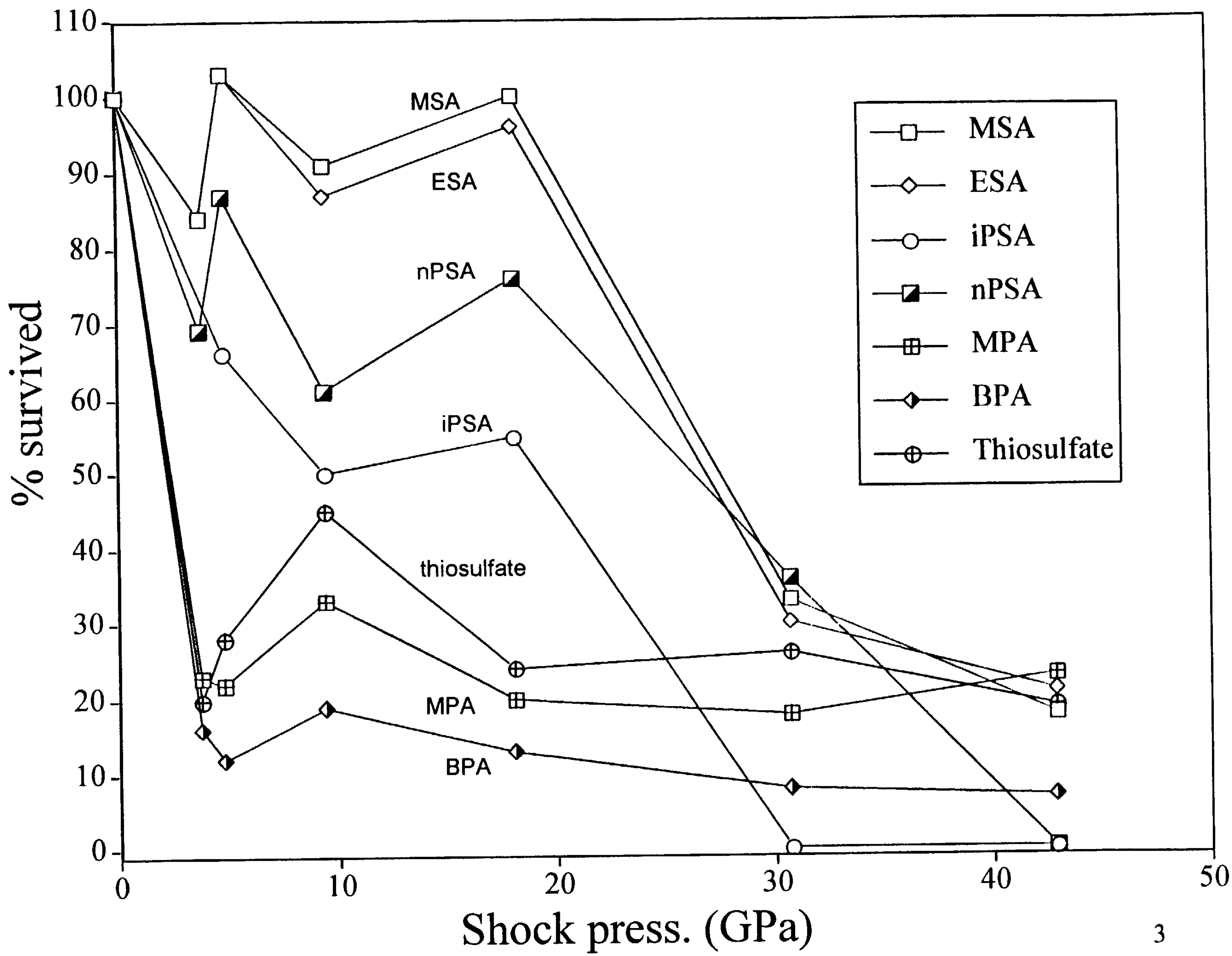
110
100
90
80
70
60
50
40
30
20
10
0
% survived
0
10
20
30
40
50
Shock press. (GPa)
MSA
ESA
nPSA
iPSA
thiosulfate
MPA
BPA
MSA
ESA
iPSA
nPSA
MPA
BPA
Thiosulfate

Table 1 Per cent Survival of compounds in the matrix of the Murchison meteorite versus shock pressure. All compounds except thiosulfate were added to the matrix. Msa = methanesulfonic acid, esa = ethanesulfonic acid, ipsa = isopropanesulfonic acid, npsa = n-propanesulfonic acid, mpa = methylphosphonic acid, bpa = butylphosphonic acid, thiosul = thiosulfate.

Shock Press. (GPa)	% Survival msa	esa	ipsa	npsa	mpa	bpa	thiosul
0	100	100	100	100	100	100	100
3.7	84	84	69	23	16		20
4.8	103	103	66	87	22	12	28
9.4	91	87	50	61	33	19	45
18.1	100	96	55	76	20	13	24
30.7	33	30	0	36	18	8	26
42.9	18	21	0	0	23	7	19