SURVIVAL OF ORGANIC COMPOUNDS ON AL FOIL UNDER STARDUST CONDITIONS. T. Henkel[1], I. C. Lyon[1], A. T. Kearsley[2], M. C. Price[3], M. J. Cole[3], M. J. Burchell[3], [1]The University of Manchester, School of Earth, Atmospheric and Environmental Sciences, Oxford Road, Manchester, M13 9PL, UK (e-mail: torsten.henkel@manchester.ac.uk), [2]National History Museum, London, UK, [3]University of Kent, Astrophysical Laboratories, Kent, UK.

Introduction: The Stardust mission successfully brought back cometary material from comet Wild 2 using aerogel as a capture medium and analysis of this material has enhanced our understanding of the formation of comets and the early Solar System [1]. Al-foil was placed between the aerogel tiles for easier handling but turned out to be an additional capture medium for cometary material [2]. It was on these Al-foils that the first presolar grain from comet Wild/2 was found [3]. The survival of inorganic material on Al foil seems to be relative straight forward and analysis has been undertaken successfully already [4].

Organic material has also been found in craters on this Al-foil [2,5]. Kearsley et al. started a systematic study to understand the impact of organic material onto Al foil and to find out how to recognize organic craters [6]. Organic material is more fragile and sensitive to heat and pressure than minerals, requiring a good understanding of any chemistry happening during the impact. To study the survival and impact chemistry of organics we have started a program where different organic materials were shot onto Stardust flight-spare Al1100 foil with impact speeds of around 6km/s, the same as those encountered during the comet rendezvous. These shots were performed using the University of Kent light gas gun (LGG) [7] and the analysis of these craters was acquired using C_{60} time-of-flight secondary ion mass spectrometry (TOFSIMS) at the University of Manchester [8].

Experimental: The light gas gun can be used for buck shots of almost any kind of materials. Polystyrene and Poly(methyl-methacrylate) (PMMA) was shot in the form of small spherules with sizes of 35 and 40µm respectively. Urea was glued together with an acrylic resin to form little spherules because the original powder would not be suitable for the LGG. The Al foil target was wrapped around an Al disk for easier handling. The sample was transferred to the TOFSIMS instrument without any further analysis to avoid contamination with the exception of the use of a light microscope to locate impact craters from the organic material. Several craters were found for each projectile material for further analysis.

The TOFSIMS analyses were undertaken with the IDLE2 instrument [8] which is equipped with a C_{60}-ion gun. C_{60} primary ions are especially suited for the analysis of organic material because the damage from the ion bombardment is much smaller than for monoatomic ions [9]. The instrument was set up for higher secondary ion yields using a big aperture for higher beam currents which results in lower spatial resolution (3-4µm), although still good enough to easily recognize any crater.

Results: Results from three organics materials are presented below with secondary ion images and the structural formula shown in figure 1.

PMMA. Due to the nature of the material it is impossible to lift whole molecules which are practically infinite in size and therefore only fragments can be expected. PMMA consists of a hydrocarbon chain with a $OCOCH_3$ side group. The latter easily breaks off and fragments resulting in several specific secondary molecules which can be detected as indicated by the red lines in figure 1: CH_3, CH_3O, CH_3OC, CH_3OCO.

Urea. The analysis of Urea not only showed fragments (NH_2, CNH_2 and $C(NH_2)_2$) but also the whole molecule ($CO(NH_2)_2$) in the mass spectrum. Urea is a relative small molecule which can be lifted unfragmented by C_{60} sputtering despite it being embedded in acrylic resin.

Polystyrene. Similar to the previous materials, polystyrene also showed fragments from its functional group. The whole molecule is near infinite in size and consists of a hydrocarbon chain with attached benzene rings. The latter break off during impacts and can be detected as C_6H_5 or C_6H_6. Complete styrene molecules have been detected in the form of C_8H_8 or C_8H_7 after a hydrogen loss.

Discussion: Most importantly, these analyses showed that organic material does survive impacts into Al foil at 6km/s. All three analyzed organics could be recognized by their specific fragments which is an indication that none or only minimal chemical alteration is happening during the impact.

The survival is astonishing considering the high velocity impact onto Al foil can create peak pressures >60GPa [10] and should also heat up the sample. The melting and boiling temperatures for these samples are in the range of 130-240°C. The survival of functional groups and even complete molecules means that temperatures are unlikely to have reached such high temperatures or at least not for long enough time to have caused complete breakdown of the parent molecules. Price et al. [11] report about the formation of larger compounds during polystyrene impacts which can neither be confirmed nor ruled out by our data.

Two of these three organic materials are large aliphatic molecules which might survive better than smaller molecules and the Urea was embedded in resin to be able to shoot it with the light gas gun which might have helped the survival.

Further work: To better understand the effect of impacts on those materials we will analyze these organics without shooting them into Al-foil and compare the mass spectra. In particular the ratios of fragments to whole molecules and to each other will be interesting to see if this fragmentation is due to C_{60} impacts or impact chemistry on the Al foil.

More organics will be shot into Al foil to widen the range of organic molecular types. These will include poly oxymethylene, coronene and pyrene.

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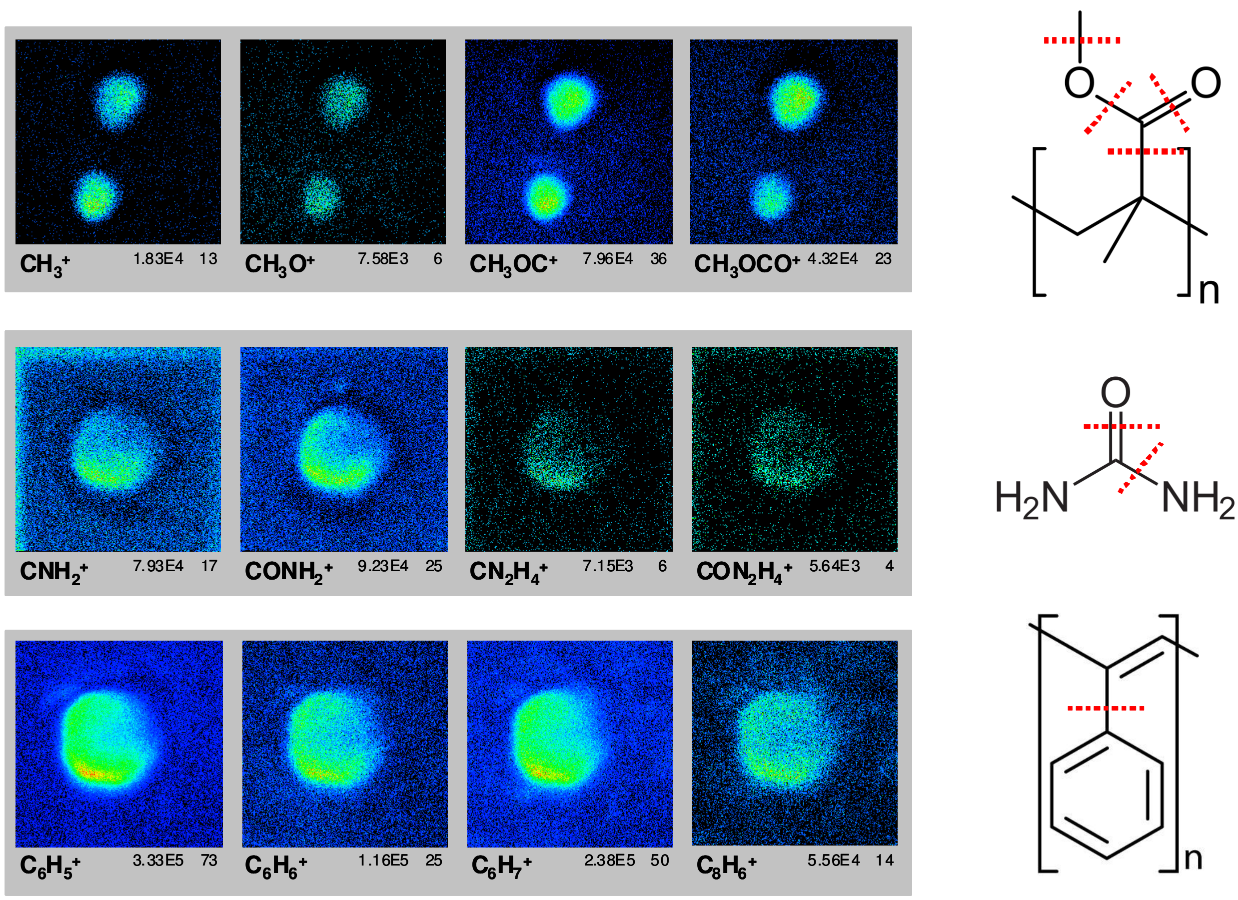

Figure 1. Secondary ion images of the organic impact craters from PMMA, Urea and Polystyrene. The numbers underneath the images are the total counts and the highest count in each image. The structural formulas on the right show the breakage of these organics during analysis. Field of view is 320µm, 250µm and 200µm from top to bottom.