

SUGARS AND SUGAR DERIVATIVES IN RESIDUES PRODUCED FROM THE UV IRRADIATION OF ASTROPHYSICAL ICE ANALOGS. M. Nuevo^{1,2}, S. A. Sandford¹, and G. Cooper¹, ¹NASA Ames Research Center, MS 245-6, Moffett Field, CA 94035, USA, ²BAER Institute, 625 2nd St., Ste. 209, Petaluma, CA 94952, USA; E-mails: michel.nuevo-1@nasa.gov; scott.a.sandford@nasa.gov.

Introduction: Carbonaceous chondrites contain a large variety of organic compounds of prebiotic interest, which include amino acids [1,2], amphiphiles [3,4], nucleobases [4,5], and sugar derivatives [7]. The presence of these compounds strongly suggests that molecules essential to life can form abiotically under astrophysical conditions. Among the sugar derivatives reported in the Murchison and Murray meteorites [7], only one sugar (dihydroxyacetone) was found, together with a variety of sugar alcohols and sugar acids containing up to 6 carbon atoms, including sugar acid derivatives of the biological sugars ribose and glucose (Fig. 1).

On the other hand, laboratory studies on the formation of complex organic molecules from the ultraviolet (UV) irradiation of simulated astrophysical ice mixtures consisting of H₂O, CO, CO₂, CH₃OH, CH₄, NH₃, etc., at low temperature have been routinely carried out in the past 15 years. These studies have shown that the organic residues recovered at room temperature contain amino acids [8-10], amphiphiles [11], nucleobases [12-15], as well as other complex organics [16-18], supporting a scenario in which molecules of prebiotic interest can form in extra-terrestrial environments.

However, until very recently, no search for the presence of sugars and sugar derivatives in laboratory residues had been carried out, despite their prebiotic significance. Several sugar alcohols, sugars, and sugar acids were first detected in residues produced from the UV irradiation of H₂O:CH₃OH ice mixtures [19,20]. Then ribose (the sugar of RNA) as well as several other sugars and sugar derivatives were identified in one residue produced from an H₂O:CH₃OH:NH₃ ice mixture [21].

Results: In this work, we carried out a systematic search for sugars and sugar-related compounds in 15 organic residues produced from the UV irradiation of simple H₂O:CH₃OH (2:1 and 5:1) ice mixtures. We show that these residues contain sugar alcohols, sugars, and sugar acids, with up to 5 carbon atoms, including ribose and several of its isomers [22]. From the relative abundances of the photoproducts identified in all the residues analyzed, we also suggest that in our experiments sugar alcohols are formed before sugars, which are themselves formed before sugar acids [22]. This is different from the chemical pathway proposed in an independent study and which ribose and several other sugar derivatives were also identified in a residue pro-

duced from the UV irradiation of an H₂O:CH₃OH:NH₃ ice mixture [21].

Finally, our results are compared with meteoritic data [7]. The distribution of photoproducts in our laboratory residues appears to be different from that in meteorites, in which only the smallest sugar (dihydroxyacetone) was identified, while several sugar alcohols and sugar acids with up to 6 carbon atoms are present. This suggests that the processes leading to the formation of the sugar derivatives found in meteorites are different from those simulated in laboratory experiments, and/or that other carbon sources in addition to CH₃OH are necessary to form sugar derivatives with a distribution that matches that in meteorites.

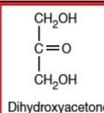
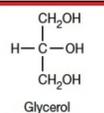
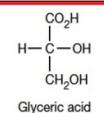
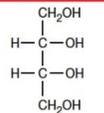
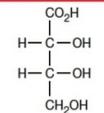
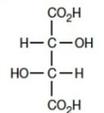
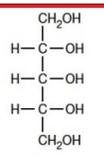
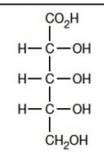
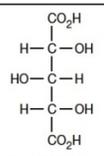
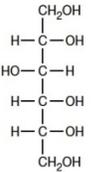
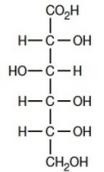
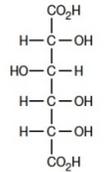
	Sugars	Sugar Alcohols	Sugar Acids	Dicarboxylic Sugar Acids
3C	 Dihydroxyacetone	 Glycerol 160 nmol/g (100%)	 Glyceric acid 80 nmol/g	—
4C	—	 Erythritol & Threitol (1%)	 Erythronic & Threonic acid (4nmol/g)	 Tartaric & Mesotartaric acid
5C	—	 Ribitol & Isomers	 Ribonic acid & Isomers	 2, 3, 4-Trihydroxy Pentanedioic acid
6C	*	 Glucitol & Isomers	 Gluconic acid & Isomers	 Glucaric acid & Isomers

Fig. 1. Sugar derivatives detected in the Murchison and Murray meteorites (from Ref. [7]) and that were searched for in our laboratory residues produced from the UV irradiation of H₂O:CH₃OH ice mixtures at low temperature. The red boxes indicate the compounds identified in our residues.

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