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The search for polyynes in electron irradiated ices of astrochemical relevance

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Abstract

We present new experimental results on the formation of polyynes by 1 keV electron irradiation of simple hydrocarbons and their mixtures with N_2 and H_2O under conditions that mimic the physical conditions on the grains in the dense molecular clouds in the interstellar medium (ISM) and the surfaces of small bodies and icy satellites in our Solar System.

1. Introduction

It is well known that polyynes ($H(-C \equiv C-)_nH$) are ubiquitous in the interstellar medium (e.g. Jolly and Benilan, 2008 and references therein). Recent astrochemical models suggest that they are formed in the solid state and then released in the gas phase by thermal and/or non-thermal processes. Compagnini at al. (2009) showed the laboratory formation of polyynes by means of Raman spectroscopy through the energetic ion bombardment of solid acetylene; while Cuylle et al. (2014) detected newly formed polyynes in the VUV spectral range after irradiation of acetylene ice (and its mixture with water) with UV-photons.

2. Experimental

Here we present new experimental results on the formation of polyynes by 1 keV electron irradiation of simple hydrocarbons and their mixtures with N_2 and H_2O under conditions that mimic the physical conditions on the grains in the dense molecular clouds in the interstellar medium (ISM) and the surfaces of small bodies and icy satellites in our Solar System. As discussed in Cuylle et al. (2014), a spectral range particularly suited for the detection of single polyynes and cyano-polyynes (i.e., with a specific number of carbon atoms in a linear chain) is the VUV spectral range, i.e. 120-340 nm. On the other hand, the more commonly used mid-IR spectral range by means of FTIR spectroscopy (4000-600 cm^{-1}) is better suited for the identification of simple single molecules and functional groups of larger species (e.g., polyynes, cyano-polyynes and the refractory organic materials formed after energetic processing of hydrocarbons). Therefore, our experiments are performed using the Open University (OU) portable high-vacuum apparatus in two different locations (i.e., the synchrotron ASTRID2 facility – ISA, Aarhus University in Denmark and the Astrochemistry laboratory at the OU in the UK) to extend the accessible spectral range from the VUV (120-340 nm) to the mid-IR (4000-800 cm^{-1}), respectively.

3. Results

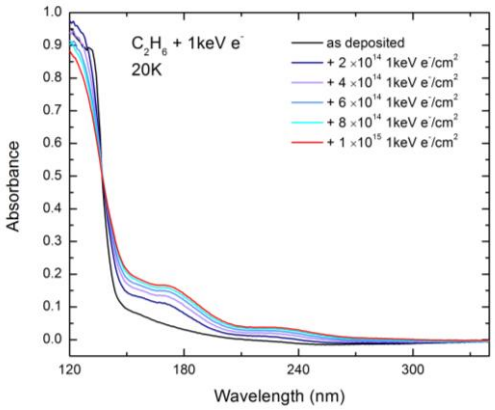

Figure 1: Irradiation of ethane (C_2H_6) with 1keV electrons at different fluencies.

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