The simplest carbon growth mechanism by atomic carbon insertion reactions and the source of DIB

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Carbon growth reactions represent one of the most fundamental chemical processes. The simplest example is the atomic carbon insertion reaction (ACIR). In ACIR, atomic carbon, :C, or its precursors, :CCO and C_3O_2, jump into the CC bond without cleaving the overall structure. As a result, no side-products are produced from this reaction (Figure 1).

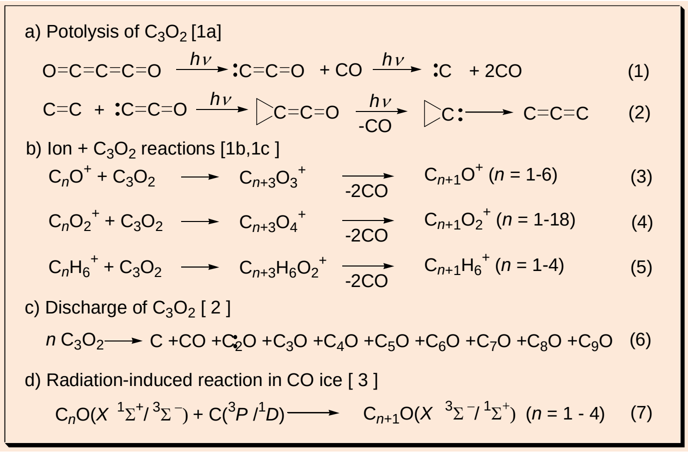

Figure 1: Some linear-carbon-chain growths by atomic-carbon-insertion reactions.

The mechanism of linear-carbon monoxides formation, C_nO (n = 2 - 9), which is synthesized in the discharge of C_3O_2, has been investigated based on the detailed analyses of FTMW spectroscopic data [2]. The relative abundances of the C_nO products, determined from their rotational spectrum intensities, agree with those for the C_nO^+ ions, which were known to be lengthened by successive mono-carbon insertions [1b]. The active chemicals in the reaction system include only :C and :CCO. Moreover, since the observed products consist exclusively of C_nO, the reaction occurs via the ACIR mechanism (Figure 2).

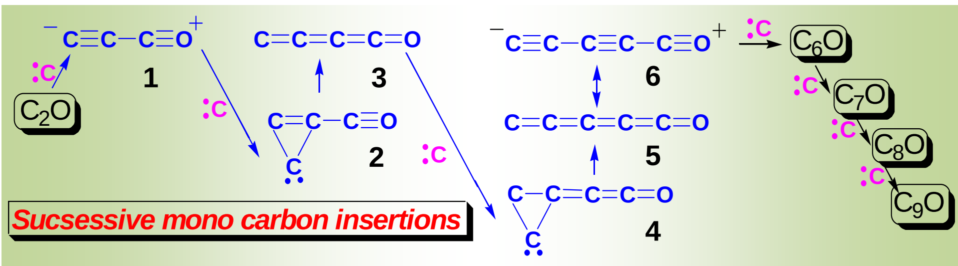

Figure 2: The proposed formation mechanism for C_nO (n = 2 - 9) by atomic carbon insertion reactions.

Nearly all of the linear-carbon-chain molecules detected in laboratories or in space, which are available on Prof. Okabayashi's homepage [4], can be interpreted by this formation mechanism. The exception is (c-H_2C_3)=C=C, which requires isomerization from (c-HC_3)-C≡CH.

ACIR is simple, as it only requires the presence of :C and a CC bond, and efficient due to its low or zero activation energy. Hence, this reaction scheme is applicable to a wide-range of carbon-based processes, in particular, to ultra low temperature or incomplete combustion conditions [5]. It is commonly thought that long carbon chains and atomic carbon primarily exist in a relatively diffuse part of the molecular cloud in space, which suggests that carbon chains are formed by ACIR.

Based on the following evidence, we can also imagine that a huge amount of the atomic carbon inserted clusters form a kind of "amorphous carbon" in interstellar space (reminiscent of the source of DIBs):

1. "Amorphous carbon" can be formed by ACIR, which is the dominant reaction at ultra low temperatures [5b].

2. While all “amorphous carbon” species have distinct structures from each other, their structures may be partially similar.
3. “Amorphous carbon” is black, implying that many absorption features fall in the UV-visible light region.
4. “Amorphous carbon” can withstand bombardment with ultraviolet photons in space.

Previous work has reported that the absorption curves for soots and quenched carbonaceous composites agree well to the absorption curves from interstellar extinction [6].

Presumably, “amorphous carbon” has a highly strained filled interior with many dangling bonds. The possible structure and formation mechanism of “amorphous carbon” will be proposed at the workshop.

References:

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[4] Prof. T. Okabayashi’s homepage, http://www.ipc.shizuoka.ac.jp/~sctokab/Okab.htm.

[5] (a) T. Ogata, et al., *Proceedings of the Carbon2007 Conference*, B083, Seattle, USA (2007); (b) *Proceedings of the Carbon2008 Conference*, P0469, Nagano, Japan (2008).

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