

Investigations of organic matter in meteorites using Fourier transform infrared and micro-Raman spectroscopic methods: Implications for origin of extraterrestrial organic matter

Bhaskar J. Saikia^{1*}, G. Parthasarathy² and Rashmi R. Borah³

¹ Department of Physics, Anandaram Dhekial Phookan College, Nagaon -782002, India

² School of Natural Sciences and Engineering, National Institute of Advanced Studies, Indian Institute of Science Campus, Bengaluru-560012, India

³ Department of Physics, Nowgong College (Autonomous), Nagaon 782001, India

*Corresponding author: vaskaradp@gmail.com

ABSTRACT

We present here the evidence for the presence of organic matters in Dergaon, Mahadevpur and Natun Balijan ordinary chondrites using Fourier transform infrared and micro-Raman spectroscopic technique. The Fourier transform infrared spectrum of these ordinary chondrites in the range 2700–3000 cm^{-1} indicates the presence of CH_3 asymmetric stretching, and CH_2 symmetric and asymmetric stretching modes due to aliphatic hydrocarbons. The micro-Raman spectrum exhibits the diamond and graphite peaks correspondingly at 1331 cm^{-1} , 1349 cm^{-1} and 1588–1618 cm^{-1} . The full wave at half maximum value correspondingly 120 cm^{-1} , 70 cm^{-1} and 17.5 cm^{-1} for Dergaon, Mahadevpur and Natun Balijan, indicate the nature of disordered phase involved shock metamorphism in the meteorites. The diamond and graphite peaks intensity ratios of ~ 1.121 , ~ 1.075 and ~ 0.532 , correspondingly for Dergaon, Mahadevpur and Natun Balijan, indicates the disordered nature of graphite. This study has strong implications in understanding of the origin of organic matters in extra-terrestrial materials and origin of extraterrestrial life.

Keywords: Organic compound; Dergaon, Mahadevpur and Natun Balijan chondrites; diamond and graphite; Infrared and micro-Raman spectroscopic methods, Extraterrestrial life

INTRODUCTION

The formation of our solar system started around 4.6 G yr ago, as this is the oldest age calculated so far for any material formed in it (Cronin et al., 1988; Cassen and Boss, 1988; Ahrens, 1990; Bouvier and Wadhwa, 2010). All solar system objects like asteroids, planetary satellites, dwarf planets, major planets and comets were formed from the nebular dust and gas within the first 10-100 million years after the formation of the first solar system solids (Montmerle et al. 2006). Most meteorites originated from different solar system bodies formed during the accretion processes that took place in the first few Myr, thus they vary in elemental and isotopic composition. Consequently, meteorites are an important source of extraterrestrial matter and their chemical and physical characteristics, texture and internal structure contribute to our understanding of the birth and early history of our solar system (McSween, 1999). The most common type of meteorites is chondrites and they originate from debris of the solar nebula (e.g., Brearley, 2003; Hutchison, 2004).

Carbon is one of the most abundant elements in the interstellar and circumstellar medium. In interstellar medium, carbon compounds occurs in different forms, including hydrocarbon dust, graphite, amorphous carbon, and diamonds. About $\sim 4 \times 10^7$ kg of extraterrestrial material, ranging in size from meter-sized meteorites down to micron-sized interplanetary dust particles (IDPs), rains down on the Earth every year (Love and Brownlee, 1993). On an average, IDPs contain about 12 wt% carbon (Thomas

et al., 1993, 1994), approximately half of which is organic matter (Flynn et al., 2004). The flux of exogenous organic matter delivered to the early Earth by IDPs and carbon-rich meteorites ~ 4 billion years ago, may have been orders of magnitude higher than the present rate with estimates of up to 10^9 kg/year of organic carbon (Jenniskens et al., 2000). The carbon phases are commonly found in carbonaceous chondrites. When C60 and C70 fullerenes were discovered along with the presence of poly aromatic hydrocarbons and carbon clusters in Allende Meteorite, Becker et al. (1999) found C60 and C70, as well as a unique distribution of remarkably stable clusters of C100 to C400. These large extra-terrestrial carbon clusters are either the first indication of higher fullerenes in Allende meteorite. Fullerenes are an allotropic modification of carbon, often termed as a molecular form of carbon, or carbon molecules. Fullerenes were discovered in 1985 by H.W. Kroto, R.F. Curl and R.E. Smalley (Frans, 2006; Misra et al., 2007) who were later awarded with the nobel prize for chemistry in 1996. The fullerene family includes a number of atomic C n clusters ($n > 20$), composed of carbon atoms on a spherical surface. Carbon atoms are usually located on the surface of the sphere at the vertices of pentagons and hexagons. In fullerenes, carbon atoms are usually present in the sp²-hybrid form and linked together by covalent bonds. Fullerene C60 is the most common and best-investigated fullerene. The spherical molecule is highly symmetric and consists of 60 carbon atoms, located at the vertices of twenty hexagons and twelve pentagons. The diameter of fullerene C60 is 0.7 nm. Becker et al. (1999) had suggested