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Preservation of chirality on minerals of astrophysical interest: A case study

Y. Keheyan
1. ISMN-CNR, c/o Dept. of Chemistry, University "La Sapienza", p.le A. Moro 5, Rome-0185, INAF-OAC, Via Moiariello 16, Naple, Italy
yeghis.keheyan@uniroma1.it, fax:+390649913951

Abstract

The aim of the present work is to analyze the influence of temperature and minerals such ilmenite, Mg_2Si, SiO_2:MgO:Fe_2O_3, etc. on the decomposition and the racemization of the most simple chiral aromatic molecule, i.e. (R+)- and (S-)-1-phenylethanol (Pe-OH). To investigate this phenomena the minerals are deposited on the quartz liner of the pyrolizer, coupled with gas chromatograph equipped with a chiral column to discriminate enantiomers and diastereoisomers. A quadrupole mass spectrometer acts as the gas chromatograph detector. Various pyrolytic experiments, at temperatures from 100 to 700°C with and without minerals as catalysts, were performed. It results that the effect of the catalyst on the decomposition and on the extent of the racemization depends on its nature. However, the crystalline silicates appears to be more active than others. As regards chemical survivability we have found that, in the presence of minerals, at temperatures up to 200°C the 1-Pe-OH enantiomers start to decompose with formation of styrene, acetophenone, and optically active benzylic ethers. The yield of the reaction of chiral benzylic ethers is temperature dependent and reaches to maximal value at 500°C. The stereochemistry of the reaction has also been investigated.

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1. Introduction

The extraterrestrial delivery of organic matter played an important role in prebiotic evolution and depends on the capability of the biomolecules to survive at high temperatures, taking into account the fact that space bodies passing through the atmosphere and impacting Earth's surface up to total decomposition of organic species. can be exposed to a significant heating[1-4]. It has also been suggested that the chiral molecules of extraterrestrial origin might have initiated the biological homochirality, thus also the chiral properties must be preserved. The aim of the present work is to analyze the influence of temperature and minerals such ilmenite, Mg_2Si, SiO_2:MgO:Fe_2O_3 (amorphous and crystalline states), wuestite, enstatite, etc. on the decomposition and the racemization of the most simple chiral aromatic molecule, i.e. (R+)- (S-)-1-phenylethanol (Pe-OH) enantiomers by pyrolysis gas chromatography mass spectrometry technique.

2. Results and discussion

Pyrolysis was carried out using a SGE's Pyrojector II microfurnace pyrolyzer. Sample simply injected into the furnace containing a quartz liner. Pyrolyzer was connected to the GC/MS system. The gas chromatograph utilized was equipped with chiral capillary column CP-Chirasil-DEX CB 25m x 0.25mm.x.0.25mn. Various pyrolytic experiments, at temperatures from 100 to 700°C with and without minerals as catalysts, were performed using pure (R+)- and (S-)-1-phenylethanol enantiomers. Our studies demonstrate that, in the absence of catalysts, pure (R+)- and (S-)-1-phenylethanol enantiomers show no sign of racemization up to 700°C. Among of all catalysts the ilmenite was found to be more efficient. The formation of chiral benzylic ethers, styrene and acetophenone were favourable at high temperatures. In all cases the racemization decreased with temperature, but at different rates.

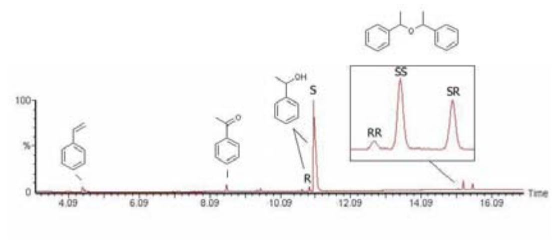

Figure 1. Pyrogram of S(-)-1-PeOH on Mg_2Si at 200°C

3. Summary and Conclusions

Intense racemization can be induced by the factors so differing as pyrolytic temperatures (>400°C) and the presence of inorganics. In general, such factors should be very common along the whole process of chemical evolution. The reactions that yield a racemizations are very suitable as a tool for detecting signs of life by observing the change of chirality with time rather than just a static chiral signal.

Acknowledgements

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