Scientific Voyage
Vol. 3, No. 2,
Page 25-29 (2022)

SCIENTIFIC VOYAGE
ISSN: 2395-5546

GCECT
Publication
Apr - Jun

Reporting of an innovative approaches to synthesis of Martian particulate matter simulant (INDMARS) and the possibility of chemical origin of life

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Abstract: The present investigation is focused on synthesizing Mars particular simulants (INDMARS-I and INDMARS-II) for the first time from India, the country of Nobel laureate Tagore. The different wet chemical route viz. combustion synthesis and aquatic salt precipitation synthesis were adopted to understand the history of the formation of matter on Mars as well as the chemical origin of life. The oxide-based composition is almost identical to the results obtained from NASA. The colour of the synthesized matter is almost identical to the image captured by the rover. The histogram of the surface topography looks exactly like the image of the rover. The specific gravity of the synthesized material is very close to that of ferrous soils. The measured values of specific gravity and tap density of INDMARS-I are 1.79 and 0.78 gm / cc and that for INDMARS-II are 1.39 and 0.56 respectively. The probability of chemical origin of life probably supports the surface topography of INDMARS-I synthesized by combustion route using urea to create high exothermicity, but the topography of INDMARS-II simulant synthesized by aquatic salt precipitation is also noteworthy.

Keywords: Mars particle stimulants; INDMARS

1 Introduction

Mars is the hotspot of astronomical studies in the upcoming time. Humanity is hopeful of colonizing Mars before the end of this century. Many space explorations are being conducted by several space agencies, both private and government, to study the geology, atmosphere and the sustainability of life on Mars. Martian regolith has been a point of interest in the eyes of many scientists. Many rovers have been sent to characterize the Martian Soil, but it could not be transported back to Earth. As a result, several institutes and agencies have devised their own Martian Soil and Dust Simulant to conduct physical, mechanical and chemical experiments and gain an insight on the processes most probable on Mars.

Razafindrambinina et al. demonstrates the method to measure the absorption spectrum of six Martian dust simulants directly with the help of photoacoustic spectroscopy. Mie theory was used with the help of absorption cross section and measured size distributions. In this way absorbing spectra was used to determine and correlate the mass percentage of iron and silica percentage in the soil [1]. Alshehhi et. al. used mask regional convolutional neural networks to detect and predict the Martian Dust Storms prevalent on the surface of Mars using satellite imagery and helps in studying the Martian meteorology which will be helpful in future human explorations. The proposed Mask R-CNN is faster and is praised for its use after training of the network. The network is able to predict 607 out 2484 dust storms on Mars [2,3,4]. Yu et al. synthesized a Martian simulant JMDS-1 from basaltic formations prevalent in Jining, southern Inner Mongolia. The synthesized simulant was then subjected to UV-NIS spectroscopy to check for absorbance and reflectance and it was also tested for thermal conductivity for potential laboratory applications [5]. Nørnberg et al. studied a fine grained magnetic iron oxide prexipitate found in Denmark for suitable simulant applications. Salten Skov 1, the simulant, showed similarity with Martian soil in terms of grain size, magnetic properties, aerosol developed a new material based standard for martian regolith simulants. The standard is developed in reference to the Rocknest, the best characterized Martian Soil till date. In accordance with this standard, MGS-1 simulants were developed, which show significant improvement over previously made simulants and is used in many studies [7,8]. Nagihara et al. used Mojave Mars Simulant (MMS) to study the varying

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thermal conductivity of martian regolith with different atmospheric conditions. Finite element thermal modelling was used to aid the thermal conductivity experiments that were otherwise suited for Earth regolith. It was found that with increasing atmospheric pressure, thermal conductivity increases by 20-25% [9].

Dikshit et al. showed that with the help of microbial induce calcite precipitation (MICP), it was possible to consolidate Martian regolith , that can otherwise be used to create bricks on Mars for construction purposes. The Simulant used in this experiment (Martian Simulant Soil) was procured from University of Central Florida and was used as the precursor for the development of martian bricks. *Sporosarcina pasteurii* was used to produce urease, which would facilitate the consolidation of the simulant via MICP[10].Guan et. al. developed a martian soil simulant NEU MARS-1 by grinding and mixing the basalts found in the Chahar volcanic mountains in Wulanchabu, China. The main phases present in the simulant were determined as plagioclase, augite and olivine. The simulant showed similar particle size ratio, chemical composition, phase composition, dielectric strength and thermal stability similar to the Martian soil[8, 11].The Martian Particulate simulant is devised to be chemically equivalent to the actual Martian Regolith found on Gale Crater. The chemical composition is kept identical in reference to the findings of Curiosity and all the rovers prior to that. The simulant thus formed can be used in many different chemical applications [6,11].

The present study is focused on synthesizing the Mars particle simulants, INDMARS-I and INDMARS-II by combustion synthesis and aquatic salt precipitation synthesis route to understand the idea about the history of the formation of matter on Mars as well as the chemical origin of life.

2 Methodology

The INDMARS-I and INDMARS-II simulants were synthesized by combustion route and aquatic precipitation pathways respectively, using a variety of pure salt graded chemicals as precursors with precise stoichiometry recorded by rovers [12]. The synthesized materials are properly dried and screen in different fraction. Topographic images of the surface of the INDMARS-I and INDMARS-II simulants were taken to compare with the image of the rover. The simulant was primarily characterised by specific gravity and tap density. The specific gravity of the simulant was measured by the standard specific gravity bottle using the principle of Archimedes. The tap density or loose density was measured by tapping the powder sample in a 10 ml cylinder with 25 stocks as per standard practice. The soft computation technique in MATLAB was adopted to draw the histogram of surface textureINDMARS-I and INDMARS-II and both are compared with image captured by rovers.

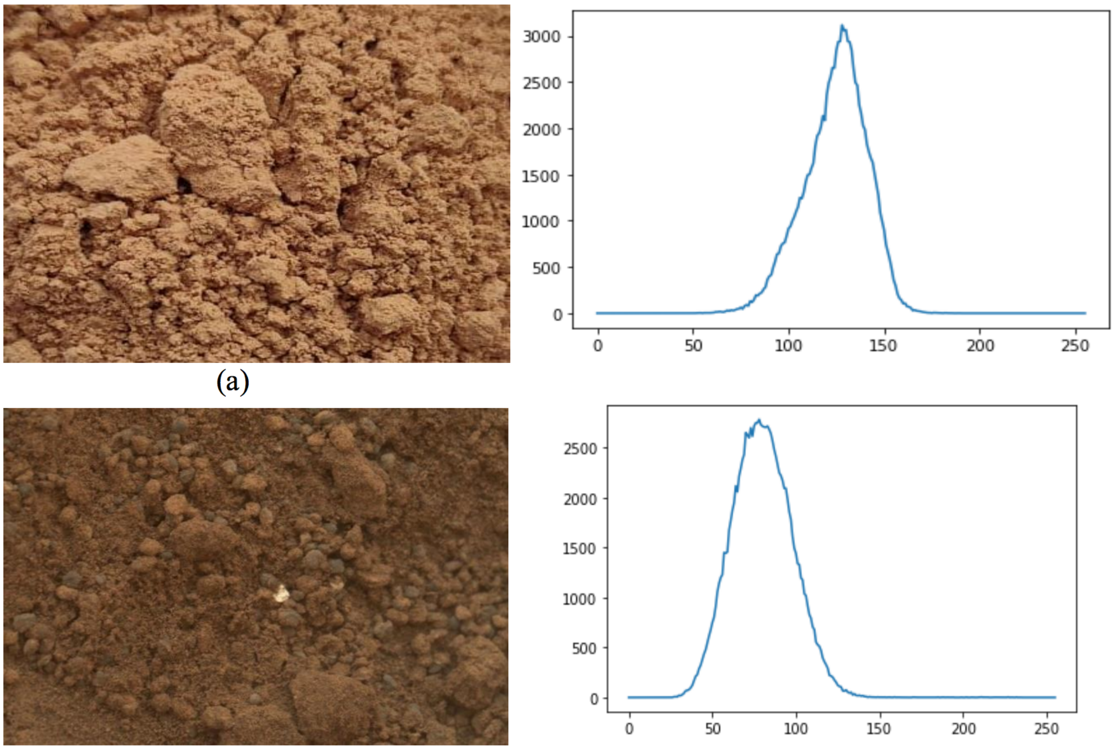
3 Results and Discussion

The chemical composition of two synthesized particulates matter INDMARS-I and INDMARS-II simulant is almost identical with the results obtained from Mars rovers by mass spectrometry [1-3]. The composition is listed in Table-1. It is composed mainly with some ceramic materials like silica and ferric oxide together with alumina, calcia and sulphur trioxides. The surface texture of INDMARS-I and INDMARS-II is totally different due to differences of synthesized routes.

Table I: Composition of Martian soil

SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	Cl
45	0.89	9.56	16.90	8.25	6.61	2.90	0.49	0.91	7.61	0.88

The colour of the simulant is reddish in nature, identical with the surface topographic colour reported by rovers. The images of INDMARS-I, INDMARS-II simulant with rovers image and their respective histogram are shown in Figs. 1 and 2.



(a)

(b)

Fig. 1: Surface topography of Martian's particulate matter (a) Synthesized (Finer fraction) of INDMARS-I, with its histogram, (b) Rover's Image with its histogram

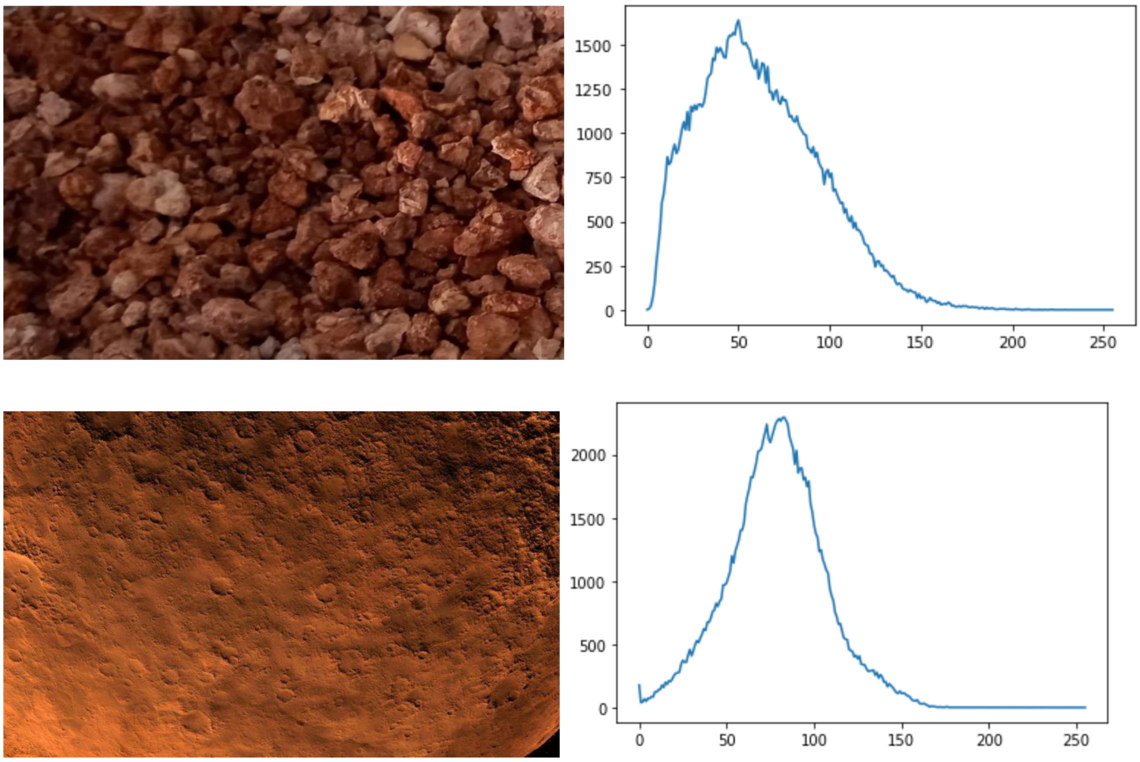


Fig. 2: Surface topography of Martian's particulate matter (a) Synthesized (Coarse fraction) with its histogram, (b) Rover's image with its histogram

The simulant synthesized by combustion route in Fig. 1, shows identical histogram as obtained from rover'simage. This indicates that combustion-type reactions may occur during the formation of matter particles on Mars. In combustion synthesis, urea was used for creation of high exothermicity. Urea is very essentially related with living cell and plays an important role in metabolism of nitrogenous compounds by animals. The body releases nitrogen using urea in many processes, converting more toxic ammonia into urea by the combination of carbon dioxide in the liver through the urea cycle[13].Plants absorb urea and are widely used as one of the sources of NPK nitrogen and widely used as fertilizer. Scientist Friedrich Ohler first discovered urea in 1828 from an inorganic substance ammonium cyanate [$NH_4CNO = CO(NH_2)_2$] without the use of biological aid, which was an important conceptual milestone in chemistry. The matter of Mars is composed of inorganic matter which should be related to the chemical origin of life. The molecular structure of water plays a significant role in supporting of life. The surface texture of the INDMARS-II and its histogram are identical to another image captured by the rovers shown in figure. The INDMARS-II was the result of salt precipitation from very dilute aqueous solution. The channels and the banks found in the Valles Marineris and the soil profiling suggest the presence of flowing water many times ago. The soil image captured by rover broadly resembles that of the surface topography as shown by INDMARS-II, which further strengthen the possibility. The mind of the scientist always cries out for the parallel behaviour of the presence of water on Mars.

4 Conclusion

This investigation concluded that the synthesis of INDMARS-I and INDMARS-II simulant was successfully achieved and reported first time from India. The chemical composition is almost identical to the NASA report. The colour of both stimulants are reddish and their respective histogram showed the close resemblance with the images capture by rovers. The Urea added simulant can be correlated with the chemical origin of life.

Acknowledgement

The authors would like to thank Prof. (Dr.) Krisnendu Chakraberty, Principal, Government college of Engineering and Ceramic Technology, Kolkata for his kind permission as well as valuable suggestions to publish this research paper. Authors also indebted to Prof. Partha Haldar, Department of Mechanical Engineering, Government college of Engineering and Ceramic Technology for his kind co-operations and great help in MATLAB operation without which it would not be possible to publish.

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