ejpmr, 2024, 11(2), 127-138

SJIF Impact Factor 6.222

EUROPEAN JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.ejpmr.com

Research Article

ISSN 2394-3211

EJPMR

CATTLE BLOOD SHELF LIFE ENHANCEMENT BY APPLYING MID-INFRARED RAYS

Umakanthan T.[1]*, Madhu Mathi[2] and Umadevi U.[3]

[1*]Veterinary hospital, Gokulam Annadhanam Temple Complex, Plot no.: 1684, Meenavilakku-Meenakshipuram Road, Anaikaraipatty Post, Bodinayakanur Taluk, Theni Dt, Tamil Nadu, India – 625582.
[2]Veterinary hospital, VadakupudhuPalayam, Erode Dt, Tamil Nadu, India – 638152.
[3]Assistant Professor, Department of Botany, The Standard Fireworks Rajaratnam College for Women, Sivakasi, Virudhunagar (Dt), Tamil Nadu, India – 626 123.

***Corresponding Author: Dr. Umakanthan T.**
Veterinary hospital, Gokulam Annadhanam Temple Complex, Plot no.: 1684, Meenavilakku-Meenakshipuram Road, Anaikaraipatty Post, Bodinayakanur Taluk, Theni Dt, Tamil Nadu, India – 625582.

Article Received on 28/11/2023 **Article Revised on 18/12/2023** **Article Accepted on 08/01/2024**

ABSTRACT
Stored human blood has short shelf life (4-6 weeks) which leads to voluntary wastage of 1.3 million units per year. To combat the wastage, increasing the shelf life of blood is necessary but it has several challenges. As a premier research to enhance the stored blood shelf life, we one-time irradiated the packaged cattle blood with 2-6µm mid-infrared. The irradiated bags containing cattle blood were stored in domestic refrigerator. It was found that the MIRGA irradiated blood samples were viable and found fit for transfusion upto 15-20 week. This paper presents the 2-6µm mid-IR induced changes in molecular level of blood that are studied using various instrumentations.

KEYWORDS: MIRGA – 2-6µm mid-IR – cattle – blood –enhanced shelf life.

INTRODUCTION
The need for increasing blood shelf life arises from the desire to improve efficiency in blood bank operations, manage inventories, and reduce the number of journeys needed to stock outlying hospitals' blood banks. There are disadvantages with hotline blood donation also. For more than a century, the developed anticoagulants for blood preservation in human and veterinary field were only the simple modification from one to another. Studies have evaluated the impact of a shorter shelf life on red blood cell inventory and availability. It has been found that a shelf life of 28 or 21 days could be accommodated with some increases in shortages or wastage, while shorter shelf lives of 14 days or fewer results in large increases in shortages and outdates **(John et al., 2014)**. Various storage solutions and antioxidants have also been investigated to prolong the viability of stored red blood cells **(Knight et al., 1996; Merlyn et al., 2012)**. Lately various methods have been explored to enhance the shelf life of stored blood, but presents several challenges including cost-effectiveness **(Leah, 2020)**. In this research we invented a water-based mid IR (2-6µm) generating atomizer named MIRGA and tested for its potential in increasing the shelf life of cattle blood. Through this approach, we aimed to enhance the storage capabilities of blood, allowing for longer shelf life and improved quality.

MATERIALS AND METHOD
MIRGA *(patent no.: 401387) (Fig 1)*is a 20-mL capacity polypropylene plastic atomizer containing an inorganic (molar mass 118.44 g/mole) water-based solution in which approximately two sextillion cations and three sextillion anions are contained. The sprayer unit has dimensions 86 × 55 × 11 mm, an orifice diameter of 0.375 mm, ejection volume 0.062 + 0.005 mL, and ejection time 0.2 s. The average pressure is 3900 Pa, and the cone liquid back pressure is 2000 N/m^2 *(Supplementary Fig (ii))*. During spraying, approximately 1-µg weight of water is lost as mist and the non-volatile material in the sprayed liquid has a concentration of 153 mg/mL. Every time spraying emits 0.06ml which contains approximately seven quintillion cations and eleven quintillion anions. Design of the MIRGA and emission of 2-6µm mid-IRhas been presented in detail by **Umakanthan *et al.*, 2022a; Umakanthan *et al.*, 2022b**. Depending on the pressure applied to the plunger, every spraying is designed to generate 2–6 µm as estimated by an FTIR (retro-reflector) interferometer instrument (Detector type D* [cm HZ1/2 - 1] MCT [2-TE cooled]) at Lightwind, Petaluma, CA, USA.

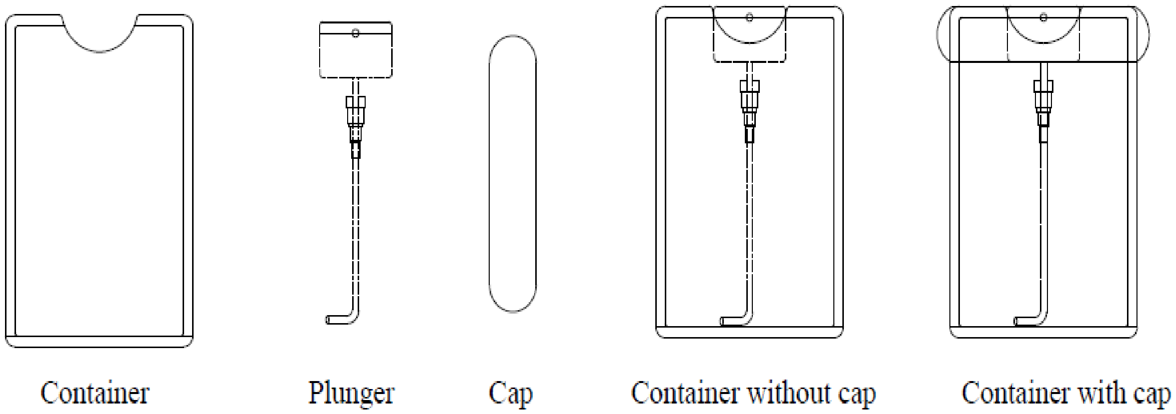


Fig. 1: MIRGA spray diagram.

Clinically healthy cows of different age, breed and reared condition were randomly selected. jugular phlebotomydone and blood samples were taken. The blood from these cows collected in human blood collection bags as routine manner. Two bagged blood (control) kept in domestic refrigerator's lower chamber. Ten bagged blood (trial) were numbered from 1 to10and correspondingly given 1 to 10number of MIRGA sprayings at the rate of one or two on one or either sides of the blood bagsand kept in the lower chamber of the same domestic refrigerator. Once in 48 hours, the blood bags were mildly titled to avoid precipitation of blood cells. Once in a week, aseptically the samples were drawn from the 12refrigerated blood bags and subjected to microscopic cellular studies and also instrumentation to identify the molecular changes. Control and trial (2, 5, 10 times sprayed) results were compared. The same trail was conducted six times at different interval for more confirmation.

Always spraying was done at a distance of 0.25-0.50 meter right away toward, the bagged blood, at the rate of one on one or both sides of bagged blood. This distance is essential for the MIRGA sprayed solution to form ion clouds, oscillation and 2-6 µm mid-IR generation. The ray can penetrate the intervening package and act on the inside blood. Close spraying doesn't generate energy. To be short, MIRGA shall be operated like a body spray but externally over the packaged material.

Method of MIRGA spraying: https://drive.google.com/open?id=1QoRwTESKfSdoJTfD--xIG9YpTDnVonGW

The instruments used to prove the: Chemical compound transformation – Liquid chromatography–mass spectrometry (LC-MS) and High Performance Liquid Chromatography (HPLC); Chemical bond changes – Fourier-transform infrared spectroscopy (FTIR); and Nuclear resonances – Proton nuclear magnetic resonance spectroscopy (1H-NMR).

RESULTS AND DISCUSSION

Control blood showed gradual decrease from normal stereochemistry after 4^{th} week, and between 5 and 6^{th} week became unfit for transfusion. Two sprayed blood on 15-20 weeks showed normal cells. The 2 times sprayed bag were transfused to randomly selected cattle of different age, breed and rearing condition and the transfusion evinced no adverse reaction. Thus >300% shelf life of the blood enhanced by MIRGA spraying. Intracellular, cytokines and mineral changes ofthe MIRGA sprayed refrigerated blood research is ongoing. For instrumentation, blood sample were taken on day 35 from non-sprayed control blood bag and on day 105 from 2, 5 and 10 sprayed blood bags.

HR-LCMS: The chromatogram of the control, 2, 5 and 10 sprayed samples. The peaks at the retention times of 13.29, 14.57, 16.59, 17.71, and 21.34 minutes corresponds to the compound's serine phosphoester, gluconic acid, pyrimidine complexes, glucagon, and cholesterol or ascorbyl-myristate respectively. It has been observed that the amounts of serine phosphoester is decreasing in the sprayed samples compared to the control, due to the lysis of the membranes and its phosphor proteins. The concentration of gluconic acid in the 2 sprayed sample is very high due to the breakage of the glycogen. However, the concentration of the gluconic acid decreases drastically in the 5 and 10 sprayed samples indicating the higher rate of respiration (Glycolysis). This also corroborated with the higher glucagon level in the control and 2 sprayed samples. The level of pyrimidine complexes in the sprayed samples is very low compared to the control because of the breakdown of the complexes by spraying. There is no change in the ascorbyl-myristate or cholesterol level in the sprayed blood samples compared to the control.*(Fig 2)*

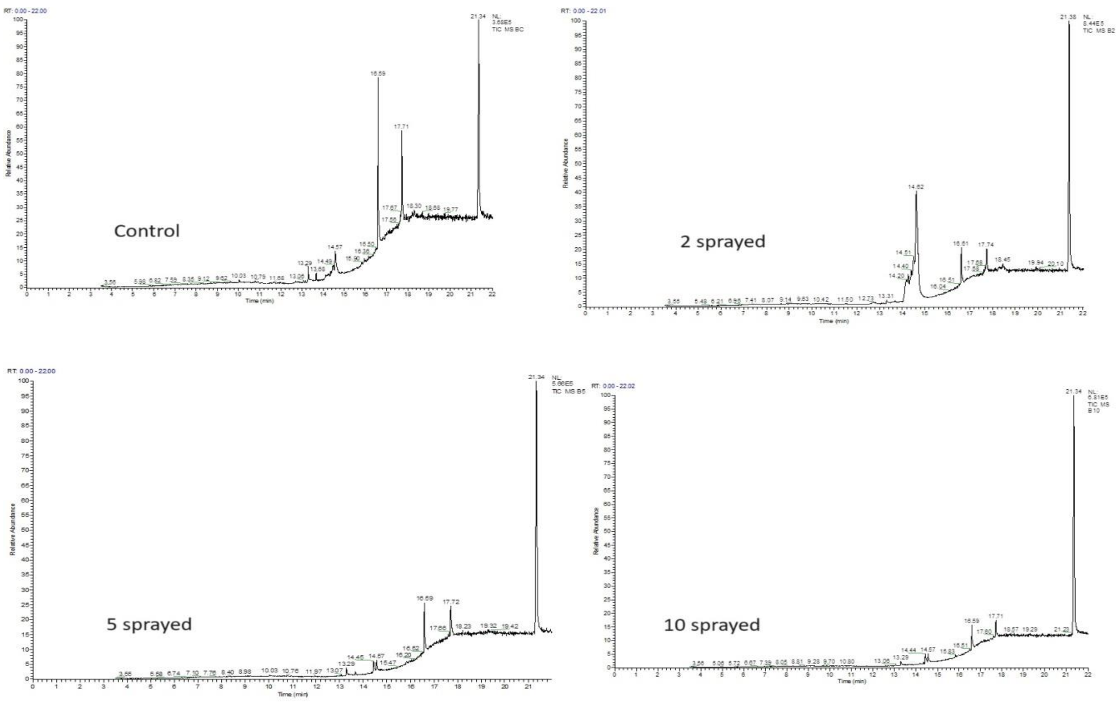


Fig. 2: LCMS spectrogram of the blood samples.

FTIR: The FTIR spectrogram of control, 2, 5 and 10 sprayed blood samples plotted without segregating the base line (a) and with the segregation of the base lines (b). There is no shift of any of the bonds. However, the intensity of the C-H stretching transmittance (Between the wave number 3200 to 3500) is found to be increased in the sprayed samples compared to the control indicating lipolysis/cell lysis of the long chain fatty acids (probably from the cell membranes and apoproteins) resulting the exposure of the C-H bonds. The increase in C-H bond stretching was found to be increasing with the number of spraying.*(Fig 3)*

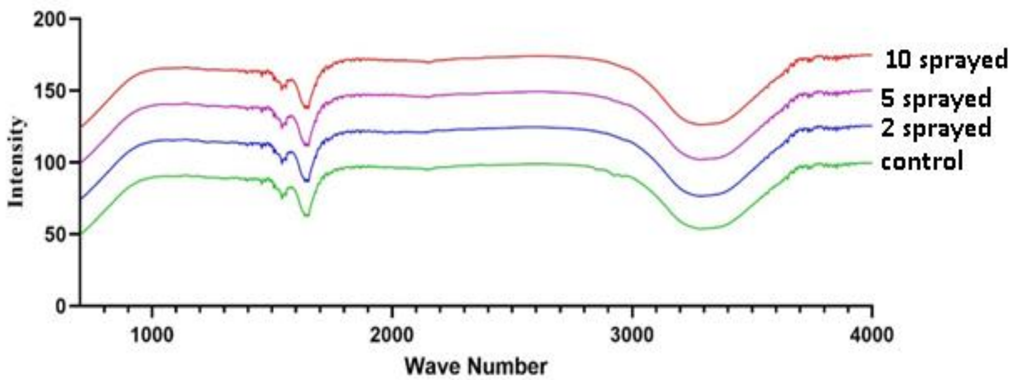


Fig. 3: FTIR spectrogram of the blood samples.

1H-NMR: The NMR spectrogram of control, 2, 5 and 10 sprayed samples. The increased intensity of the peaks in the chemical shift region between 0.8 and 1.5 in the 5 and 10 sprayed samples compared to the control indicates the increased amounts of amino acids. This is due to the proteolysis in medium and higher radiated blood samples. In addition, the lactic acid peak intensity at 4.5 is higher compared to the control samples. This implicates that due to increased number of spraying, the rate of respiration in the blood cells is higher because of the oxidative stress resulting anaerobic respiration and increased lactate. This is further confirmed from the decreased glucose intensity in the 5 and 10 sprayed blood samples compared to the control at 3.5 ppm. *(Fig 4)*

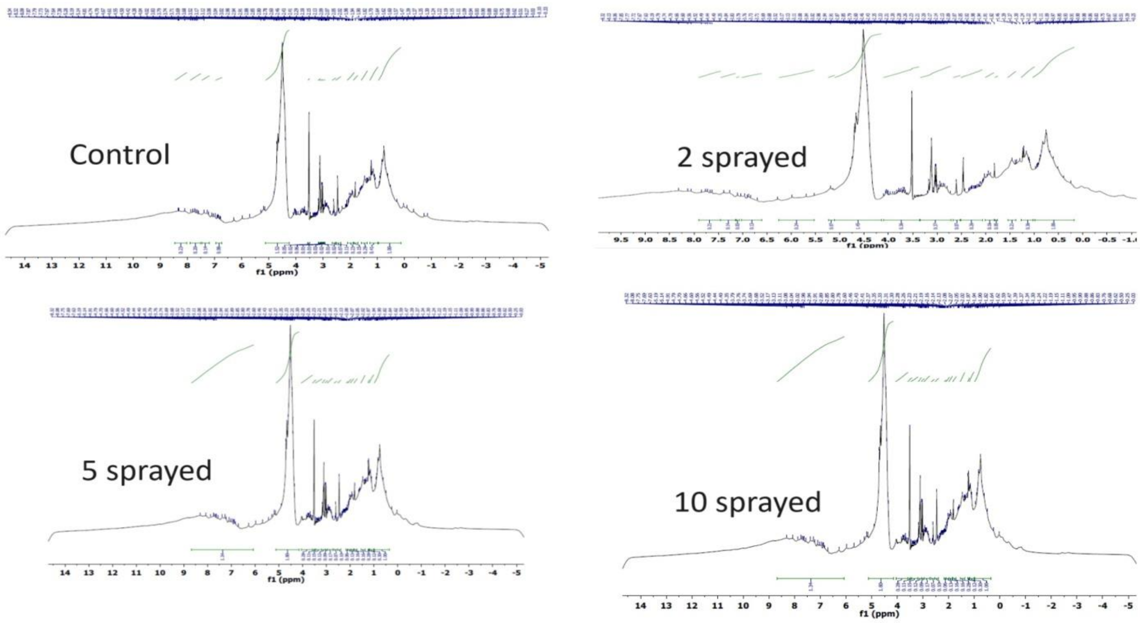


Fig. 4: NMR spectrogram of the blood samples.

Compared with control data, all the instrumentation data proved that, MIRGA depending on number of sprayings had altered the bonds, thereby structure, leading to enhanced/ decreased inherent characters.

Invention background, definition, technique of mid-IR generation from MIRGA, toxicological study on MIRGA, safety of the MIRGA sprayed usables and primeval and future scope of MIRGA have been described by **Umakanthan *et al*., 2022a**, **Umakanthanet *al*., 2023c, Umakanthan*et al*., 2023d**.

Invention background

The four observable states of matter (solid, liquid, gas, plasma) are composed of intermolecular and intramolecular bonds. The inherent characteristics of neutrons, protons and electrons are unique, however, difference in their numbers is what constitutes different atoms and how these atoms bind together develop into different molecules with unique characters. In the electromagnetic wave (EMW) spectrum *(Fig 5)* mid-IR region is vital and interesting for many applications since that region coincides with the internal vibration of most molecules **(CORDIS, European commission).** Almost all thermal radiation on the earth surface lies in the mid-IR region, 66% of the sun's energy we receive is infrared **(Aboud*et al*., 2019)** and is absorbed and radiated by all particles on the earth. Naturally, at molecular level, interaction of mid-IR wavelength energy elicits rotational and vibrational modes (from about 4500-500 cm^{-1} roughly 2.2 to 20 microns) through a change in dipole movement leading to chemical bond alteration **(Girard, 2014)**.

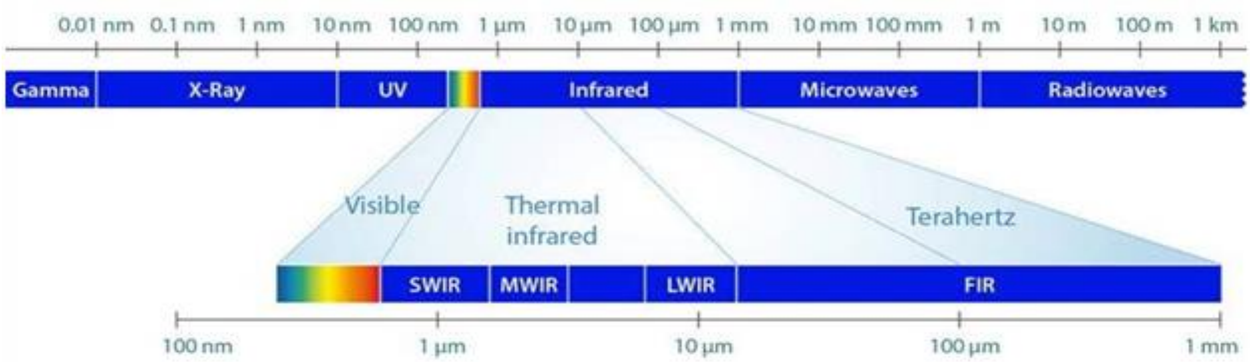


Fig. 5: Electromagnetic Spectrum.

During our research we observed: **(A)** In all objects, even though atoms always remain as atoms their chemical bond parameters are continuously prone to alteration by cosmic and physical energies (eg: EMW, heat, pressure, humidity) causing the bonds compression/stretching/bending **(Alvarez *et al.*, 2012; Smith, 1999; Shankar, 2017; Mohan, 2004)**, breaking **(McMakin, 2011; Moss, 2011)** and new bond formation **(Raven, 2012).** These alterations ultimately lead to the change in the physicochemical characters of the objects.

(B) The dynamic, constant, mutual influences of EMW among earth, celestials and living bodies are continuously causing alterations in the inherent physiochemical characters of earthly objects, like enhancement due to optimum dose of energy or decrease/ destruction due to more dose of energy *(detailed below)*. Thus based on these concepts, the MIRGA was developed to alter bond parameters thereby potentiate any usables' natural characters.

MIRGA definition

We define MIRGA as *'a harmless, economical atomizer containing an imbalanced ratio of ions suspended in water, which influence the natural potency of target substances by generating mid-IR while spraying'*.

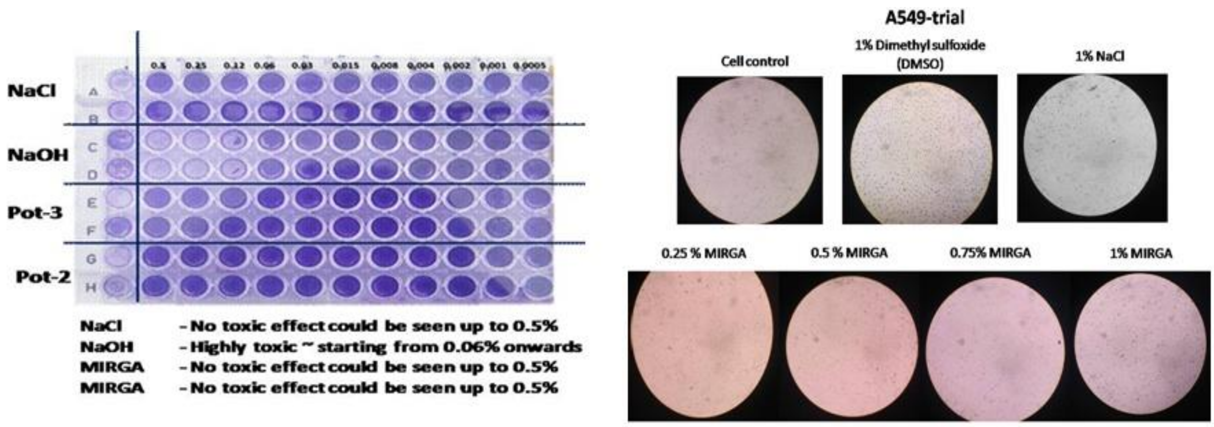
Technique of mid-IR generation from MIRGA

We designed MIRGA as to accommodate an imbalanced ratio of ions suspended in water in their fundamental state and can move as free particles. The solution has very little background frequency of detectable disintegration which is less than that of cosmic events whereas even humans have more radioactivity (Around 10 microns) **(Ashcroft, 2000; Sanders, 2014)**. We designed *MIRGA to generate energy based on various below given processes like,* **(A)** spraying leads to ionization (electron getting separated from atom) and the pathway for electron re-absorption are also many, due to these two oscillatory processes energy generated. **(B)** while spraying, water-based ionic solution gets excited/charged, which in turn leads to oscillation among the imbalanced ions **(Verheest, 2000)** in their excited state, resulting in the emission of photons **(Keping*et al.*, 2004; Fauchais*et al.*, 2014)**. **(C)** Though low electromagnetic field exists between charged particles of the MIRGA's ionic solution, during spraying the induced oscillation between these charged particles produces energy **(Wendish*et al.*, 2009; Singh, 2009; Prasad, 2017; Pople, 1999)**. **(D)** Also, in the natural rainfall process, more energy is required to break water bonds for creating smaller water droplets from the clouds **(Barry *et al.*, 1998)**. Therefore, these droplets should have more stored energy and then travels down at a velocity from a specific distance thus gaining also a kinetic energy. When the rain hits the earth's surface, it forms a very thin film of mid-IR (nearly 6 micron), hence there is a net heat gain **(Barry *et al.*, 1998; Eniday, 2019)**. We simulated this rainfall's energy gaining process also in MIRGA i.e., when imbalanced ions in liquid media are atomized, the ejected smaller droplets should have higher internal energy as well as an acquired kinetic energy and the energy emitted by breaking the surface tension. From trial and experience, we calibrated an ejection pressure to obtain a desired fine mist, and minimized the evaporation rate by altering the pH and density of the solution. Also considering other facts like, the accelerated ions in the sprayed ionic clouds collide among them and generate energy **(Krishnakumar, 2019)**, we incorporated those phenomena in our atomizer and designed in such a way to emit energy in the 2-6 µm mid-IR range.

The inorganic compounds used in the generation of MIR are a perspective for biomedical applications **(Tishkevich*et al.*, 2019; Dukenbayev*et al.*, 2019)**. It is also a new synthesis method for preparation of functional material (2-6 µm mid-IR) **(Kozlovskiy*et al.*, 2021; El-Shater*et al.*, 2022)**. It is well known that the combination of different compounds, which have excellent electronic properties, leads to new composite materials, which have earned great technological interest in recent years**(Kozlovskiy*et al.*, *2021;* Almessiere*et al.*, 2022)**.

Toxicological study on MIRGA

Even though, MIRGA generates the safe 2-6 µm mid-IR energy, and moreover spraying is done 0.25–0.50 meter externally right away to packaged consumables, we also wanted to study the MIRGA's toxicity effect by cytotoxicity assay. *In-vitro* Vero, A549 and Human dermal fibroblast cells study proved that MIRGA sprayed mist was non-toxic in any way **(Fig 6)**.



a) Trial with Toxicity assay of MIRGA at various concentrations

b) Trial with A549 cells

Fig. 6: MIRGA's toxicological studies.

Field studies also showed that, MIRGA spray is eco-friendly, non-toxic, non-irritant to soft tissues such as cornea, safe to infants even if sprayed directly, needs no skill but easy to handle (like perfume body spray), and highly economical (USD 0.30 per MIRGA unit which emits 300 sprayings).

Safety of MIRGA sprayed usables

In our nearly two-decades of research, we observed MIRGA induced bond altered target substances had not shown any adverse reaction upon consumption/use. As a comparison, to assure the safety of the bond altered targets' millennium long consumption by human/ living kinds; we submit that in nature, **(A)** Stereochemical configuration has great influence on taste **(Williamson *et al.*, 2011)** e.g. variety of mango, grapes, rice, etc., **(B)** Cooking and digestive enzymes break chemical bonds thereby soften our edibles. And, as an example; raw rice on water-boiling to boiled rice; rice on raw heat to puffed rice; rice on boiling and drying to flat rice; rice on pressure to rice flour **(Scanlon *et al.*, 2019; Kowtaluk, 2006)**, each by-product has its unique aroma, taste, texture and shelf life but with same molecular formula $C_6H_{10}O_5$), **(C)** In food industry, sensory attributes and shelf-life are enhanced by altering the food's chemical bonds using various irradiation processes like, radappertization, radicidation, raduriaztion**(Sivasankar, 2014)**, **(D)** On heating, ice to water to steam manifestations are due to changes in the hydrogen bonding, where steam has negligible hydrogen bonding **(Day, 1999)** but chemical composition (H_2O) remains the same **(Raymond,2010)**.

MIRGA's primeval and future scope

The water based MIRGA could be the first novel pioneer potentiating technology. This type of atomizer technology also seems to be present with the extra-terrestrials for their therapeutic use during visitations **(Blue planet project)**.

In various usables, a range from 30% to 173% potentiation has been achieved by us. Even considering the least 30% in some usables have resulted in 30% economic, resource, and ecological savings as well as health benefits. But there is a knowledge gap between potentiation from 30% to at least 100% for all usables, which can be filled-up by refining MIRGA's ionic solution, concentrations, atomizer pressures, other parameters and even formulating a better solution.

Using MIRGA, we conducted experiments which resulted in resource savings with edible oils, vegetables, fruits, food, coffee, tea, alcohol, tobacco, cocoa, edible salts, sugar, herbal, cement, spices, chemicals, pharmaceuticals, dairy products, liquid and gaseous fuels, and vaccine. Human and veterinary disease therapy and were included in these studies, and the results are promising. The laboratory analysis of these substances revealed the altered chemical bonds, configuration and chemical compound transformation. In foodstuffs, detoxification of agrochemical residues resulted as well as enhancement of sensory attributes and shelflife. These results are being separately submitted for publication. The individual results are about to be published.

A variety of mid-IR emitters are now available e.g. silicon photonic devices **(CMOS Emerging Technologies, 2012)**, cascade lasers (quantum and interband) **(Jung *et al.*, 2017)**, non-cascade based lasers, chalcogenidefibre-based photonic devices **(Sincore*et al.*, 2018)** and suspended-core tellurium-based chalcogenidefibre photonic devices **(Bo *et al.*, 2018)**. These emitters are not as cost-effective as MIRGA, and useful only in astronomy, military, medicine, industry as well in the laboratory. They are much too complex in daily domestic applications for the average user.

Because of MIRGA's wide range of applications, we believe that MIRGA will definitely resonate in many scientific researches such as biophotonics, therapeutics, health, ecology and many other fields. Our further research on MIRGA and its other manifestations which we developed namely MIRGA salt, MIRGA vapor and MIRGA plasma in human endeavors is dynamically now ongoing.

Literature comparison

Blood shelf life can be increased through various methods. One method involves transferring blood to a sterile container and mixing it with an anticoagulant. The mixture is then centrifuged to separate the red blood cells, which are placed in a sterile tube. The red blood cells are then irradiated with a laser, resulting in an enhancement of shelf life by 66% **(Al-Khalid et al., 2012)**. Another method involves biostimulation by a He-Ne laser, which has been shown to enhance the shelf life of stored blood to 63 days **(Al-Khalid et al., 2015)**. Additionally, blood storage containers containing a CeONP composition and/or coating on an object surface have been found to increase the useful storage lifespan of blood **(Mina et al., 2019)**. One recent approach is the use of hybrid blood collection tubes (BCTs) that combine the breakage resistance of plastic and the shelf life approaching that of glass **(Christopher et al., 2020)**. These hybrid BCTs have demonstrated a shelf life of at least 2 years with less than 10% draw volume variation, which is significantly longer than standard polyethylene terephthalate (PET) BCTs. Another method involves irradiating the red blood cells with a laser that emanates a visible light wavelength of about 633 nm for a time period of about 24 hours, which has been shown to enhance the shelf life of donor blood by 66% **(Challa et al., 2020)**. These methods offer potential solutions for extending the shelf life of blood and ensuring its effectiveness for clinical use but offers many limitations. However, using MIRGA technology, the shelf life of blood can be extended upto 15-20 weeks rather than in days, in a cost effective and safe manner.

Similar desirable results in coffee, tea, cocoa, edible salts and terminalia were achieved using MIRGA spraying by **Umakanthan*et al*., 2022a; Umakanthan*et al*., 2022b; Umakanthan*et al*., 2023c; Umakanthan*et al*., 2023d.**

Benefits of MIRGA technology in blood

1. Now this trial is useful in bovine transfusion but may pave way for enhancement of human transfusion blood shelf life and research.
2. Human energy can be saved.
3. Most useful to remote area, during epidemics, war, major accidents etc.
4. Can be preserved in domestic refrigerator, hence economical.

CONCLUSION

2-6 µm mid-IR mid-infrared irradiated cattle blood showed an extended shelf life of 300% and found fit for transfusion. Future research using this technology will definitely have good result in human blood also.

REFERENCES

1. John, T., Blake, Matthew, Hardy. Evaluating the impact of shorter shelf life for red blood cells with a generic simulation, 2014.
2. Knight JA, Searles DA, Clayton FC. The effect of desferrioxamine on stored erythrocytes: lipid peroxidation, deformability, and morphology. Ann Clin Lab Sci, 1996; 26(4): 283-90. PMID: 8800428.
3. Merlyn, H., Sayers, Jeff, Centilli, Jeff, Centilli. What if shelf life becomes a consideration in ordering red blood cells. Transfusion, 2012. doi: 10.1111/J.1537-2995.2011.03412.X
4. Leah, S. News Feature: Making and storing blood to save lives. Proceedings of the National Academy of Sciences of the United States of America, 2020 doi: 10.1073/PNAS.2001649117
5. Umakanthan, Mathi M, Decaffeination and improvement of taste, flavor and health safety of coffee and tea using mid-infrared wavelength rays. Heliyon, 2022; e11338: 8(11). doi: 10.1016/j.heliyon.2022.e11338
6. Umakanthan T, Mathi M, Quantitative reduction of heavy metals and caffeine in cocoa using mid-infrared spectrum irradiation. Journal of the Indian Chemical Society, 2022; 100(1). doi: 10.1016/j.jics.2022.100861.
7. Umakanthan, T., & Mathi, M. Increasing saltiness of salts (NaCl) using mid-infrared radiation to reduce the health hazards. Food Science & Nutrition, 2023; 11: 3535– 3549. https://doi.org/10.1002/fsn3.3342
8. Umakanthan, MadhuMathi, Potentiation of Siddha medicine using Muppu (Universal Potentiator). International Journal of Pharmaceutical Research and Applications, 2023; 8, 4: 2070-2084.
9. CORDIS, European commission. New advances in mid-infrared laser technology, Compact, high-energy, and wavelength-diverse coherent mid-infrared source. Available at: https://cordis.europa.eu/project/rcn/99977/brief/en (last accessed on 27.01.2019)
10. Aboud S, Altemimi A, Al-Hilphy A, Lee Y C, Cacciola F, molecules A Comprehensive Review on Infrared Heating Applications in Food Processing. Molecules, 2019; 24: 2-21. 10.3390/molecules24224125.
11. Girard J E, Principles of Environmental Chemistry, Jones & Bartlett Learning, USA, 2014; 3: 99.
12. Alvarez A, Prieto M, Fourier Transform Infrared spectroscopy in Food Microbiology, Springer Science & Business Media, 2012; 3.
13. Smith B C, Infrared Spectral Interpretation: A Systematic Approach, CRC Press, LLC, 1999; 7.
14. Shankar D R, Remote Sensing of Soils. Germany: Springer-Verlag GmbH, 2017; 268.
15. Mohan J, Organic Spectroscopy: Principles and Applications, Alpha science international Ltd., Harrow, UK, 2004; 2: 19. Available at: https://books.google.co.in/books?id=fA08Uy5DR0QC&printsec=frontcover&dq=Jag+Mohan.+Organic+Spectroscopy:+Principles+and+Applications&hl=en&sa=X&ved=0ahUKEwjHpcHUi9fgAhXXFIgKHXvRCpIQ6AEIKjAA#v=onepage&q=Jag%20Mohan.%20Organic%20Spectroscopy%3A%20Principles%20and%20Applications&f=false
16. McMakin C, Frequency specific Microcurrent in pain management E-book, Elsevier, China, 2011; 30.
17. Moss D, Biomedical Applications of Synchrotron Infrared Microspectroscopy: A Practical Approach, Royal Society of Chemistry, UK, 2011; 58.
18. Raven P H, Berg L R, Hassenzahl D M, Environment, John Wiley & Sons, Inc., USA, 2012; 45. Available at: https://books.google.co.in/books?id=QVpO2R51JBIC&pg=RA1-PA45&dq=electromagnetic+waves+make+form+new+bonds&hl=en&sa=X&ved=0ahUKEwiTnO2amMbjAhUJ3o8KHSfkAJEQ6AEIMjAB#v=onepage&q=electromagnetic%20waves%20make%20form%20new%20bonds&f=false
19. Ashcroft F, Life at the Extremes: The Science of Survival, University of California Press, California, 2000; 122.
20. Sanders R H, Revealing the Heart of the Galaxy, Cambridge University Press, USA, 2014; 70.
21. Verheest F. Waves in Dusty Space Plasmas, Kluwer Academic Publishers, Netherlands, 2000; 89.
22. Keping S, Yu G, Recent developments in Applied Electrostatics (ICAES2004): Proceedings of the Fifth International Conference on Applied Electrostatics, Elsevier Ltd., UK, 2004; 87.
23. FauchaisP, Heberlein J V R, Boulos J I, Thermal Spray Fundamentals From Powder to Part. Springer Science & Business Media, New York, 2014; 84
24. Wendish M, Brenguier J L, 2019. Airborne Measurements for environmental Research: Methods and Instruments, Wiley-VCH. Available at: https://books.google.co.uk/books?id=tHdwhn-c5mgC&pg=PT419&dq=A+regularly+oscillating+c

harge+produces+a+harmonic+electromagnetic+waves+Manfred&hl=en&sa=X&ved=0ahUKEwjBqdv75tvgAhWpSxUIHbQ_D0gQ6AEIKjAA#v=onepage&q=A%20regularly%20oscillating%20charge%20produces%20a%20harmonic%20electromagnetic%20waves%20Manfred&f=false (last accessed on 27.02.2019)
25. Singh K C, Basic Physics, PHL Learning Private Limited, New Delhi, 2009; 413.
26. Prasad M, Soul, God and Buddha in Language of Science, Notion Press, Chennai, 2017.
27. Pople S, Complete Physics, Oxford University Press, Oxford, 1999; 166.
28. Barry R, Chorley R, Atmosphere, Weather and Climate, Routledge, London, 1998; 7: 51.
29. Eniday: https://www.eniday.com/en/sparks_en/harnessing-the-energy-of-rain/ (last accessed on 06.02.2019)
30. Krishnakumar T Application of Microwave Heating In Food Industry, 2019; 10.13140/RG.2.2.27035.72488.
31. Tishkevich D I, Korolkov I V, Kozlovskiy A L, Anisovich M, Vinnik D A, Ermekova A E, Vorobjova A I, Shumskaya E E, Zubar T I, Trukhanov S V, Zdorovets M V, Trukhanov A V, 2019. Immobilization of boron-rich compound on Fe_3O_4 nanoparticles: Stability and cytotoxicity, J. Alloys Compd. 797, 573-581. https://doi.org/10.1016/j.jallcom.2019.05.075.
32. Dukenbayev K, Korolkov I V, Tishkevich D I, Kozlovskiy A L, Trukhanov S V, Gorin Y G, Shumskaya E , Kaniukov E Y, Vinnik D A, Zdorovets M V, Anisovich M, Trukhanov A V, Tosi D, Molardi C, Fe_3O_4 nanoparticles for complex targeted delivery and boron neutron capture therapy, Nanomaterials, 2019; 494. https://doi.org/10.3390/nano9040494.
33. KozlovskiyA L, Alina A, Zdorovets M V, Study of the effect of ion irradiation on increasing the photocatalytic activity of WO_3 microparticles, J. Mater. Sci.: Mater. Electron, 2021; 32: 3863-3877. https://doi.org/10.1007/s10854-020-05130-8
34. El-Shater R E, Shimy H E, Saafan S A, Darwish M A, Zhou D, Trukhanov A V, Trukhanov S V, Fakhry F, Synthesis, characterization, and magnetic properties of Mnnanoferrites, J. Alloys Compd, 2022; 928. 166954. https://doi.org/10.1016/j.jallcom.2022.166954
35. Kozlovskiy A L, Zdorovets M V, Effect of doping of $Ce^{4+/3+}$ on optical, strength and shielding properties of $(0.5\text{-}x)TeO_2\text{-}0.25MoO\text{-}0.25Bi_2O_3\text{-}xCeO_2$ glasses, Mater. Chem. Phys, 2021; 263. 124444. https://doi.org/10.1016/j.matchemphys.2021.124444
36. Almessiere M A, Algarou N A, Slimani Y, Sadaqat A, Baykal A, Manikandan A, Trukhanov S V, Trukhanov A V, Ercan I, Investigation of exchange coupling and microwave properties of hard/soft $(SrNi_{0.02}Zr_{0.01}Fe_{11.96}O_{19})/(CoFe_2O_4)_x$ nanocomposites , Mat. Today Nano, 2022. 100186. https://doi.org/10.1016/j.mtnano.2022.100186
37. Yi G, Semiconductor Nanostructures for Optoelectronic Devices: Processing, Characterization and Applications. Berlin, Heidelberg: Springer-Verlag, 2012; 198.
38. Esmaeili K, Viremedy, Homeopathic Remedies, and Energy Healing Remedies as Information – including Remedies; A Synopsis [Revision Aug 2015; E-pub.: Aug.2015] (First Pub: 2013). Google books, 2015; 43.
39. Atkins P, Paula J, Physical Chemistry for the Life Sciences, Oxford university press, Oxford, 2011; 365.
40. Datta S N, O'Trindle C, Illas F, Theoretical and Computational Aspects of Magnetic Organic Molecules. Imperial College Press, London, 2014; 224.
41. Sommer A, Caron A, Fecht H J, Tuning Nanoscopic Water Layers on Hydrophobic and Hydrophilic Surfaces with Laser Light. Langmuir: the ACS journal of surfaces and colloids, 2008; 24: 635-6. 10.1021/la7032737.
42. Sommer A, Zhu D, Mester A, Försterling H D, Pulsed Laser Light Forces Cancer Cells to Absorb Anticancer Drugs - The Role of Water in Nanomedicine. Artificial cells, blood substitutes, and immobilization biotechnology, 2011; 39: 169-73. 10.3109/10731199.2010.516262.
43. Scanlan N, Complementary Medicine for Veterinary Technicians and Nurses, Wiley-Blackwell publishing, USA, 2011.
44. Kowtaluk H, Food for today Tata McGraw-Hill Publishing Company Limited, NewDelhi, 2006; 9,9: 456.
45. Sivasankar B. Food Processing and preservation, PHI Learning Private Limited, Delhi, 2014; 246.
46. Day, Ecosystems: Oceans. Routledge Taylor & Francis Group, London and New York, 1999; 44.
47. Raymond K W, General Organic and Biological Chemistry, John Wiley & Sons, Inc., USA, 2010; 176: 6.
48. Blue planet project: Alien Technical research–25, Westchester Camp, Office of the Central Research #3.CODE: ARAMISIII–ADR3-24SM, 80-81.
49. CMOS Emerging Technologies. CMOSET, 2012. Abstracts, p49. Available at: https://books.google.co.in/books?id=3XVYC-yBgksC&pg=PA49&dq=mid+infra#v=onepage&q&f=false
50. Jung D, Bank S, Lee M L, Wasserman D, Next-generation mid-infrared sources. Journal of Optics, 2017; 19(12): 123001. doi:10.1088/2040-8986/aa939b.
51. Sincore A, Cook J, Tan F, El Halawany A, Riggins A, McDaniel S, Cook G, Martyshkin D V, Fedorov V V, Mirov S B, Shah L, Abouraddy A F, Richardson M C, Schepler K L, High power single-mode delivery of mid-infrared sources through

chalcogenide fiber. Optics Express, 2018; 26(6): 7313. doi:10.1364/oe.26.007313
52. Bo W, Zheming Z, Xunsi W, Youmei T, Nan M, Peng C, Zugang X, Zijun L, Peiqing Z, Xiang S, Qiuhua N, Shixun D, Rongping W, Mid-infrared supercontinuum generation in a suspended-core tellurium-based chalcogenide fiber. Optical Materials Express, 2018; 8(5): 1341. doi:10.1364/ome.8.001341.
53. Al-Khalid, I, Zuhaier., Mohamad, S., AlSalhi., Vadivel, Masilamani. Method for enhancing the shelf life of donor blood by laser biostimulation, 2012.
54. Al-Khalid, Isam, Zuhaier., Kosa, Mohammad., S., Devanesan., Mohamad, S., AlSalhi., Saradh, Prasad., Vadivel, Masilamani. Shelf-Life Enhancement of Donor Blood by He-Ne Laser Biostimulation. Current Science, 2015. doi: 10.18520/CS/V109/I6/1151-1153
55. Mina, N., Anousheh, S., Hamed, A., Amir, A, Anvar, S, Kakoolaki. Food-grade nanoemulsions and their fabrication methods to increase shelf life, 2019.
56. Christopher, W., Adam, P., Breeland., M, S., Wills., Martin, E., Baltazar-Lopez. Hybrid Blood Collection Tubes: Combining the Best Attributes of Glass and Plastic for Safety and Shelf life, 2020. doi: 10.1177/2472630320915842
57. Challa, K., Beverly, A., Rzigalinski. Blood preservation compositions, devices, and uses thereof, 2020.
58. Leah, S. News Feature: Making and storing blood to save lives.. Proceedings of the National Academy of Sciences of the United States of America, 2020. doi: 10.1073/PNAS.2001649117

Author contribution

Umakanthan: Conceptualization, Methodology, Supervision, Validation.
Madhu Mathi: Data curation, Investigation, Visualization, Writing - Original draft preparation.
Umadevi: Project administration, Resources
Umakanthan, Madhu Mathi: Writing- Reviewing and Editing.

Competing interest

In accordance with the journal's policy and our ethical obligation as researchers, we submit that the authors Dr.Umakanthan and Dr.Madhu Mathi are the inventors and patentee of Indian patent for MIRGA *(granted-patent no.: 401387)* which is a major material employed in this study.

Data and Materials availability

All data is available in the manuscript and supplementary materials.

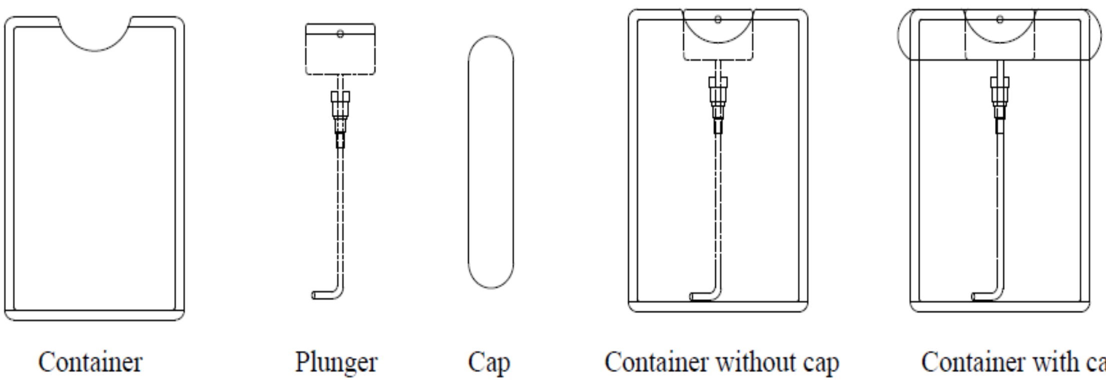
Funding

The authors received no specific funding for this research.

Supplementary material

Supplementary video V1: Method of MIRGA spraying https://drive.google.com/open?id=1QoRwTESKfSdoJTfD--xIG9YpTDnVonGW

Supplementary figure F1: MIRGA spray diagram



Supplementary Text T1: Details of MIRGA

MIRGA *(patent no.: 401387)* is a 20-mL capacity polypropylene plastic atomizer containing an inorganic (molar mass 118.44 g/mole) water-based solution in which approximately two sextillion cations and three sextillion anions are contained. The sprayer unit has dimensions 86 × 55 × 11 mm, an orifice diameter of 0.375 mm, ejection volume 0.062 + 0.005 mL, and ejection time 0.2 s. The average pressure is 3900 Pa, and the cone liquid back pressure is 2000 N/m^2 *(Supplementary Fig (ii))*. During spraying, approximately 1-µg weight of water is lost as mist and the non-volatile material in the sprayed liquid has a concentration of 153 mg/mL. Every time spraying emits 0.06ml which contains approximately seven quintillion cations and eleven quintillion anions.

Depending on the pressure applied to the plunger, every spraying is designed to generate 2–6 µm as estimated by an FTIR (retro-reflector) interferometer instrument (Detector type D* [cm HZ1/2 - 1] MCT [2-TE cooled]) at Lightwind, Petaluma, CA, USA.

Supplementary Text T2: Detailed Discussion

1. Detailed discussion[1]

1.1. Invention background

The four observable states of matter (solid, liquid, gas, and plasma) are composed of intermolecular and intramolecular bonds. The inherent characteristics of neutrons, protons and electrons are unique, however, differences in their numbers are what constitute different atoms, and how these atoms bind together develops into different molecules with unique characteristics. In the electromagnetic wave (EMW) spectrum, the mid-IR region is vital and interesting for many applications since this region coincides with the internal vibration of most molecules.[2] Almost all thermal radiation on the surface of the Earth lies in the mid-IR region, indeed, 66% of the Sun's energy we receive is infrared[3] and is absorbed and radiated by all particles on the Earth. At the molecular level, the interaction of mid-IR wavelength energy elicits rotational and vibrational modes (from about 4500–500 cm^{-1}, roughly 2.2 to 20 microns) through a change in the dipole movement, leading to chemical bond alterations.[4]

During our research we have observed: **(A)** In all objects, even though atoms always remain as atoms, their chemical bond parameters are continuously prone to alteration by cosmic and physical energies (e.g.: EMW, heat, pressure, and humidity) causing the bonds to compress/stretch/bend,[5-8] break,[9,10] or new bonds to be formed.[11] These alterations ultimately lead to changes in the physicochemical characteristics of the objects. **(B)** The dynamic, constant, and mutual influences of EMW among the Earth and the celestial and living bodies are continuously causing alterations in the inherent physiochemical characters of earthly objects, for instance, enhancement due to an optimum dose of energy or decrease/destruction due to a high dose of energy (detailed below). Thus, based on these concepts, MIRGA was developed to alter the bond parameters, thereby potentiating the natural characteristics of products.

1.2. ***MIRGA definition***

We define MIRGA as *'a harmless, economical atomizer containing an imbalanced ratio of ions suspended in water, which influence the natural potency of target substances by generating mid-IR while spraying'*.

1.3. Technique of mid-IR generation from MIRGA

We designed MIRGA as to accommodate an imbalanced ratio of ions suspended in water in their fundamental state, which can move as free particles. The solution exhibits very little detectable background frequency, below even that of cosmic events. By comparison humans emit more radioactivity (around 10 microns).[12,13] We designed MIRGA to generate energy based on various processes such as:**(A)** spraying leads to ionization (electrons getting separated from atoms) and many pathways for electron re-absorption; due to these two oscillatory processes, energy is generated;**(B)** while spraying, a water-based ionic solution gets excited/charged, which in turn leads to oscillation among the imbalanced ions[14] in their excited state, resulting in the emission of photons.[15,16] **(C)**although a low electromagnetic field exists between the charged particles of the MIRGA's ionic solution, during spraying the induced oscillation between these charged particles produces energy.[17-21] and**(D)** in the natural rainfall process, more energy is required to break the water bonds for creating smaller water droplets.[22] Therefore, these droplets should have more stored energy, which then travels down at velocity from a specific distance, thus gaining kinetic energy. When the rain hits the Earth's surface, it forms a very thin film of mid-IR (nearly 6 micron), hence there is a net heat gain.[22,23] We simulated this rainfall's energy-gaining process in MIRGA(i.e., when imbalanced ions in liquid media are atomized, the ejected smaller droplets should have higher internal energy as well as acquired kinetic energy, and the energy emitted by breaking the surface tension). From trial and error, we calibrated the ejection pressure to obtain a desired fine mist, and minimized the evaporation rate by altering the pH and density of the solution. Moreover, the accelerated ions in the sprayed ionic clouds collide among themselves and generate energy.[24] thus, we incorporated these phenomena in our atomizer and designed it in such a way as to emit energy in the 2–6 µm mid-IR depending on the given plunger pressure.

Yousif et al.[25] described this process as a photodissociation of molecules caused by the absorption of photons from sunlight, including those of infrared radiation, visible light, and ultraviolet light, leading to changes in the molecular structure.

1.4. Safety of MIRGA-sprayed products

In our nearly two-decades of research, we have observed that MIRGA-induced bond-altered target substances do not show any adverse reaction upon consumption/use. In nature, **(A)** Stereochemical configuration has great influence on taste[26] (e.g., varieties of mango, grapes, rice, etc.), **(B)** Cooking and digestive enzymes break chemical bonds, thereby softening foods. This indicates that alterations in chemical bonds occur naturally and do not represent a risk to human health. As an example, boiled rice, puffed rice, flat rice, and rice flour have a unique aroma, taste, texture, and shelf-life but conserving the same molecular formula ($C_6H_{10}O_5$).**(C)** In the food industry, sensory attributes and shelf-life are enhanced by altering the food's chemical bonds using various irradiation processes like radappertization, radicidation, and radurization.[27] **(D)** Upon heating, water changes from ice to liquid to steam, which are manifestations of changes in the hydrogen bonds[28] but the chemical composition (H_2O) remains the same.[29]

1.5. MIRGA's primeval and future scope

The water-based MIRGA could be the first novel potentiating technology. This type of atomizer technology also seems to be present with the extra-terrestrials for their therapeutic use during visitations.[30]

In various products, we have achieved a range from 30% to 173% potentiation. Even the smaller improvement resulted in 30% monetary and resource savings as well as health benefits. However, there is a knowledge gap between potentiation from 30% to at least 100% for all products, which can be filled-up by refining MIRGA's ionic solution, concentration, atomizer pressure, and other parameters and even formulating a better solution.

Various mid-IR emitters are now available (e.g., silicon photonic devices,[31] cascade lasers quantum and interband,[32] non-cascade-based lasers, chalcogenide fiber-based photonic devices,[33] and suspended-core tellurium-based chalcogenide fiber photonic devices.[34] These emitters are not as cost-effective as MIRGA and are useful only in astronomy, military, medicine, industry, and research applications. These emitters are too complex for domestic application by the average user.

Because of MIRGA's wide range of applications, we believe that this technique will resonate in many scientific fields including biophotonics, therapeutics, health, ecology, and others. We are currently conducting research on MIRGA and its applications, namely MIRGA salt, MIRGA vapor and MIRGA plasma.

REFERENCES

1. Umakanthan, Mathi M, Decaffeination and improvement of taste, flavor and health safety of coffee and tea using mid-infrared wavelength rays. Heliyon, 2022; e11338: 8(11). doi: 10.1016/j.heliyon.2022.e11338
2. CORDIS, European commission. New advances in mid-infrared laser technology, Compact, high-energy, and wavelength-diverse coherent mid-infrared source. Available at: https://cordis.europa.eu/project/rcn/99977/brief/en (last accessed on 27.01.2019)
3. A. Salam, A. Ammar, A.H. Asaad, L. Yi-Chen, C. Francesco, Molecules A Comprehensive Review on Infrared Heating Applications in Food Processing. Molecules, 2019; 24: 2-21. doi: 10.3390/molecules24224125.
4. J. E. Girard, Principles of Environmental Chemistry, third ed., Jones & Bartlett Learning, USA, 2014; 99.
5. James E. Girard, Principles of Environmental Chemistry, Jones & Bartlett Learning, USA, 2024; 3: 99.
6. Avelion Alvarez and Miguel Prieto, Fourier Transform Infrared spectroscopy in Food Microbiology, Springer Science & Business Media, 2012; 3.
7. Brian C. Smith. Infrared Spectral Interpretation: A Systematic Approach, CRC Press, LLC, 1999; 7.
8. Dwivedi Ravi Shankar, Remote Sensing of Soils. Germany: Springer-Verlag GmbH, 2017; 268.
9. Jag Mohan. Organic Spectroscopy: Principles and Applications, 2nd edition, Alpha science international Ltd., Harrow, UK, 2004; 19. Available at: https://books.google.co.in/books?id=fA08Uy5DR0QC&printsec=frontcover&dq=Jag+Mohan.+Organic+Spectroscopy:+Principles+and+Applications&hl=en&sa=X&ved=0ahUKEwjHpcHUi9fgAhXXFIgKHXvRCpIQ6AEIKjAA#v=onepage&q=Jag%20Mohan.%20Organic%20Spectroscopy%3A%20Principles%20and%20Applications&f=false
10. Carolyn McMakin, Frequency specific Microcurrent in pain management E-book, Elsevier, China, 2011; 30.
11. David Moss, Biomedical Applications of Synchrotron Infrared Microspectroscopy: A Practical Approach, Royal Society of Chemistry, UK, 2011; 58.
12. Peter H. Raven, Linda R. Berg, David M. Hassenzahl, Environment, John Wiley & Sons, Inc., USA, 2012; 45. Available at: https://books.google.co.in/books?id=QVpO2R51JBIC&pg=RA1-PA45&dq=electromagnetic+waves+make+form+new+bonds&hl=en&sa=X&ved=0ahUKEwiTnO2amMbjAhUJ3o8KHSfkAJEQ6AEIMjAB#v=onepage&q=electromagnetic%20waves%20make%20form%20new%20bonds&f=false
13. Frances Ashcroft, Life at the Extremes: The Science of Survival, University of California Press, California, 2000; 122.
14. Robert H. Sanders, Revealing the Heart of the Galaxy, Cambridge University Press, USA, 2024; 70.
15. Frank Verheest. Waves in Dusty Space Plasmas, Kluwer Academic Publishers, Netherlands, 2000; 89.
16. Sun Keping, Gefei Yu. Recent developments in Applied Electrostatics (ICAES): Proceedings of the Fifth International Conference on Applied Electrostatics, Elsevier Ltd., UK, 2004; 87.
17. Pierre L. Fauchais, Joachim V.R. Heberlein, Maher I. Boulos. Thermal Spray Fundamentals From Powder to Part. Springer Science & Business Media, New York, 2014; 84.
18. Manfred Wendish, Jean-Louis Brenguier. Airborne Measurements for environmental Research: Methods and Instruments, Wiley-VCH. Available at: https://books.google.co.uk/books?id=tHdwhn-c5mgC&pg=PT419&dq=A+regularly+oscillating+charge+produces+a+harmonic+electromagnetic+waves+Manfred&hl=en&sa=X&ved=0ahUKEwjBqdv75tvgAhWpSxUIHbQ_D0gQ6AEIKjAA#v=onepage&q=A%20regularly%20oscillating%20charge%20produces%20a%20harmonic%20electromagnetic%20waves%20Manfred&f=false (last accessed on 27.02.2019)
19. Kongbam Chandramani Singh, Basic Physics, PHL Learning Private Limited, New Delhi, 2009; 413.

20. Mathura Prasad. Soul, God and Buddha in Language of Science, Notion Press, Chennai, 2017.
21. Stephen Pople, Complete Physics, Oxford University Press, Oxford, 1999; 166.
22. Roger Barry, Richard Chorley, Atmosphere, Weather and Climate, 7th edition, Routledge, London, 1998; 7: 51.
23. Eniday: https://www.eniday.com/en/sparks_en/harnessing-the-energy-of-rain/ (last accessed on 06.02.2019)
24. Krishnakumar, T Application of Microwave Heating In Food Industry, 2019. 10.13140/RG.2.2.27035.72488.
25. Yousif, E., & Haddad, R. Photodegradation and photostabilization of polymers, especially polystyrene: review. SpringerPlus, 2013; 2: 398. https://doi.org/10.1186/2193-1801-2-398
26. Kenneth L., Williamson, Katherine M. Masters. Macroscale and Microscale Organic Experiments, 6th edition, Brooks/ Cole C engage learning, CA, 2011; 720.
27. Sivasankar B. Food Processing and preservation, PHI Learning Private Limited, Delhi, 2014; 246.
28. Trevor Day, Ecosystems: Oceans. Routledge Taylor & Francis Group, London and New York, 1999; 44.
29. Kenneth W. Raymond, General Organic and Biological Chemistry, John Wiley & Sons, Inc., USA, 2010; 3: 176.
30. Blue planet project: Alien Technical research–25, Westchester Camp, Office of the Central Research #3.CODE: ARAMISIII–ADR3-24SM, 80-81.
31. CMOS Emerging Technologies. CMOSET, Abstracts, 2012; 49. Available at: https://books.google.co.in/books?id=3XVYC-yBgksC&pg=PA49&dq=mid+infra#v=onepage&q&f=false
32. Jung, D., Bank, S., Lee, M. L., & Wasserman, D. Next-generation mid-infrared sources. Journal of Optics, 2017; 19(12): 123001. doi:10.1088/2040-8986/aa939b.
33. Sincore, A. & Cook, Justin & Tan, Felix & El Halawany, Ahmed & Riggins, A. & McDaniel, S. & Cook, G. & Martyshkin, Dmitry & Fedorov, V.V. & Mirov, Sergey & Shah, L. & Abouraddy, A. & Richardson, M. & Schepler, Kenneth. High power single-mode delivery of mid-infrared sources through chalcogenide fiber. Optics Express, 2018; 26(6): 7313. doi:10.1364/oe.26.007313.
34. Wu, Bo & Zhao, Zheming & Wang, Xunsi & Tian, Youmei & Mi, Nan & Chen, Peng & Xue, Zugang & Liu, Zijun & Zhang, Peiqing & Shen, Xiang & Nie, Qiuhua & Dai, Shaocong & Wang, R.P. Mid-infrared supercontinuum generation in a suspended-core tellurium-based chalcogenide fiber. Optical Materials Express, 2018; 8(5): 1341. doi:10.1364/ome.8.001341.