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TECHNOLOGYOFFUELCONSUMPTIONANDEMISSIONREDUCTIONANDENHANCEDELECTRICITYGENERATIONUSINGMIDINFRAREDRAYSALASERADDITIVE

Technology of Fuel Consumption and Emission Reduction, and Enhanced Electricity Generation using Mid-Infrared Rays – A Laser Additive

Umakanthan [α], Madhu Mathi [σ], Umadevi [ρ] & Sivaramakrishnan [ω]

Abstract- Efficient utilization of available resources is a promising research direction. In-depth studies can provide a unique platform for reducing fuel consumption while simultaneously reducing pollution, thereby avoiding environmental pollution and health hazards for this purpose various fuel addictive are being used now. A laser additive for liquid and gaseous fuel is yet to be developed. In this context, we successfully used the 2-6 mid-infrared spectrum as a fuel additive. To generate mid-infrared we invented a hand-lit pocket-size mid-infrared generating automizer (MIRGA). The trial fuels were irradiated with this spectral range, which caused chemical changes in the fuels. MIRGA irritated gasoline and diesel consumption was reduced by 30-50% and 12-58% respectively. Also the emission by 1-62% and 1-68% respectively depending on the engine model. The irradiated liquified petroleum gas had extended utility days by 28 - 35% and gasoline power generators showed 28 % more electricity generation. These results were compared with non-irradiated fuels. This technology is safe, simple to implement at both the manufacturer and consumer levels, and cost-effective. This work demonstrates the MIRGA technology as an intriguing playground for revealing the effects of MIR on fuel chemistry, and the benefits are discussed here.

Keywords: mid-infrared ray – fuels – irradiation-consumption – pollution – reduction – safe – economical – resource saving.

I. Introduction

Now, the automobile industry's urgent need is that internal combustion engines should consume less fuel produce more power, and also emit less pollutants *(Krishania et al., 2020)*. On the contrary, emerging volatile fuel prices, economic policies, and war increased the number of vehicles and roads, thereby increasing pollution. The primary sources of air pollution are motor vehicle emissions and fossil fuel combustion *(Kalghatgi et al., 2016)*. Comparatively diesel engines emit massive quantities of pollution which causes serious health (Dizziness to lung cancer) and environmental (global warming and acid rain, smog, etc.) hazards *(Abdellatief et al., 2021; Daud et al., 2022)*. In spite of stringent measures, automobile pollution is a big challenge to our new technical world *(Zhang et al., 2020)*. To overcome the hazards fuel component alteration, especially varieties of additives are in use but are to be improved.

The most used liquid fuels include diesel, gasoline, and kerosene. In developing countries, the most important household fuel is kerosene *(Lam et al., 2012)*, contributing to the 4.3 million deaths that occur due to household air pollution (HAP) *(Collins, 2014)*. Like other fuels, liquefied petroleum gas (LPG), an alternative fuel, has dynamic price increases and supply associated with high demand *(Grand View Research, 2016)*.

Our technology of employing mid-IR is one of the new ways to overcome the said problems. Infrared wavelength is essential for earthly molecules. Daily received 66% of the sun's radiant energy is infrared *(Aboud et al., 2019)*. In the infrared spectrum mid-infrared (mid-IR) is the safest range *(Prasad, 2005; Pereira et al., 2011)* which penetrates most obscurants and coincides with nearly all molecules of Earth *(Waynant et al., 2001; Toor et al., 2018),* cause chemical bond changes, hence target substance's (fuels) physicochemical property alteration *(Waynant et al., 2001; Tsai et al., 2017)*. We have invented a mid-infrared generating atomizer (MIRGA). In field and laboratory conditions, the tanked liquid and gaseous fuels were subjected to MIRGA irradiation. Their favorable efficiency and results are compared with the control (non-irradiated) and detailed here. We have also subjected the irradiated and non-irradiated fuels to instrumentations such as GC-MS, NMR, and FTIR and compared. Herein, we show that the comparatively MIRGA platform is safe, cost-effective, easy to use, and eco-friendly. Review literature showed that this laser fuel additive technology is the first of its kind to generate significant results.

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II. MATERIALS AND METHODS

a) *Design of Mid-Infrared Generating Atomizer (MIRGA)*

MIRGA (patent no. 401387) is a 20-ml capacity polypropylene plastic atomizer containing a water-based inorganic solution (molar mass 118.44 g/mol) (containing approximately two sextillion cations and three sextillion anions). The atomizer has dimensions of 86 x 55 x 11 mm, an orifice diameter of 0.375 mm, an ejection volume of 0.062 ± 0.005 ml, an ejection time of 0.2 s, an average pressure of 3900 pascals, and a cone liquid back pressure of 2000 N/m2 (Fig. 1). Design of the MIRGA and emission of 2-6μm mid-IR has been presented in detail by *Umakanthan et al., 2022a; Umakanthan et al., 2022b; Umakanthan et al., 2023c; Umakanthan et al., 2023d.* Every time spraying emits 0.06ml which contains approximately seven quintillion cations and eleven quintillion anions.

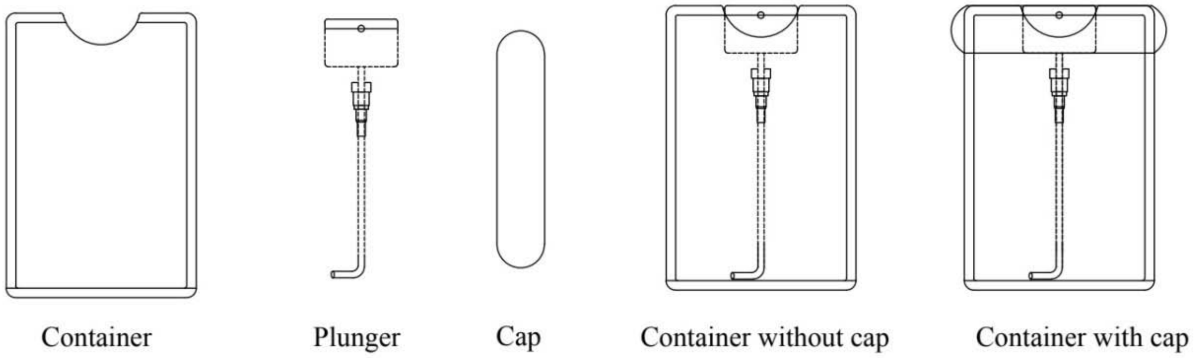


Fig. 1: MIRGA's Design

The inorganic chemicals used in generation of mid-infrared are a perspective for biomedical applications *(Tishkevich et al., 2019; Dukenbayev et al., 2019).* This new method of synthesis the functional materials (mid-infrared) *(Kozlovskiy et al., 2021; El-Shater et al., 2022).* Different chemicals with excellent electronic properties leads to new composite material and has attracted great technological intrest now *(Kozlovskiy & Zdorovets, 2021; Almessiere et al., 2022).*

During spraying, approximately 1 µg of water as mist is lost, and the non-volatile material in the sprayed liquid is 153 mg/ml. Depending on the pressure (varies with the user) applied to the plunger, every spray is designed to generate 2–6 μm mid-IR (Fig. 2) *(Umakanthan et al., 2022a).* Each spray emits 0.06 ml of solution, which contains approximately seven quintillion cations and eleven quintillion anions.

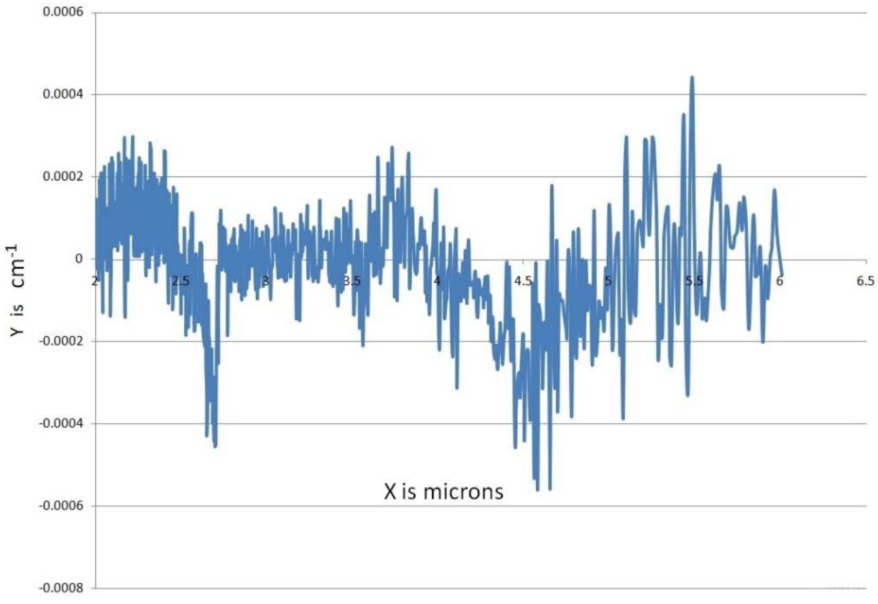


Fig. 2: Estimation of 2-6 μm Mid-Infrared While Spraying MIRGA Atomizer

b) *Method of Mirga Spraying*

The spraying should be done from the fuel tank mouth towards the fuel. This distance is essential for the MIRGA-sprayed solution to form ion clouds, to and fro oscillations, and generate mid-IR. The generated mid-IR can penetrate the intervening material—In an LPG iron cylinder—and act on the fuel contents inside (Fig. 3a, Fig. 3b) *(Method of MIRGA spraying presented in Supplementary video V1)*.

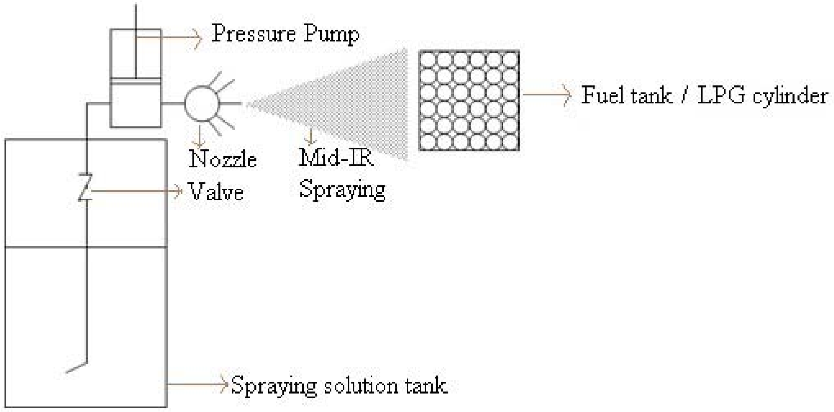


Fig. 3a: Schematic Apparatus of MIRGA

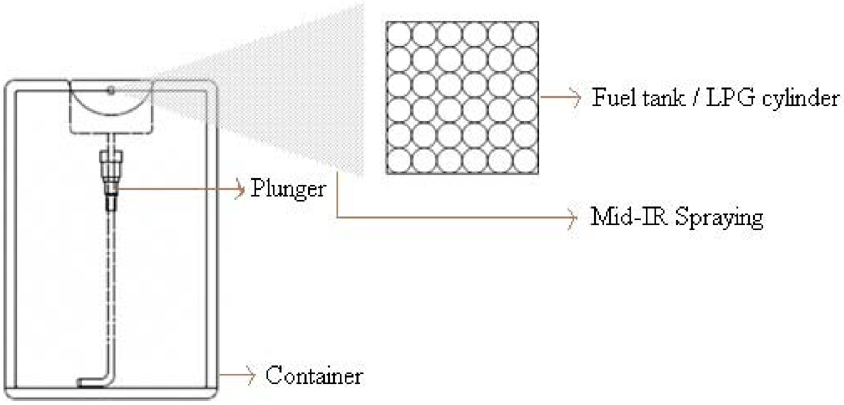


Fig. 3b: Schematic Apparatus of MIRGA

c) *Vehicles Employed in the Study*

Two, three, and four-wheeled vehicles, as well as multi-axle vehicles, of different brands, models, cylinders, horsepower, and manufacturing years, were employed. Nearly 500 such vehicles that have been operating on the road for more than a decade were tested with commercially available liquid fuels.

Kerosene-based equipment, viz., power generators, old model engines, and traditional lamps, was also filled with commercially available kerosene and tested. Commercial gasoline power generators and domestic LPG cylinders (14.2 kg) with stove burners were employed. The expert panel was comprised of 65 housewives (n = 65). LPG experts from refineries also contributed to their outside opinion.

Diesel, gasoline, and kerosene samples were all taken from the same brand and batch, and different brands and batches were never mixed.

d) *Instrumentations Employed in the Study*

Response variables and instruments included: Chemical compound transformation – Gas chromatography-mass spectrometry (GC-MS); Chemical bond changes – Fourier-transform infrared spectroscopy (FTIR); and Nuclear resonances – Proton nuclear magnetic resonance (1H-NMR).

GC-MS: Agilent technologies, 7820 GC system, 5977E MSD, Colomn DB-5, Over temperature 100-270^{0}C, Detector MS, Flow rate of 1.2, Carrier gas used was Helium.

FTIR: IR AFFINITY I – FTIR Spectrophotometer, FTIR 7600, Shimadzu

1H-NMR: The 1 H NMR spectra of the compounds were performed on a 500 MHz Bruker AVANCE III spectrometer operating at 500.13 MHz, using a 5-mm broad band (BBO) probe equipped with a z-gradient coil

(Bruker-Biospin, Switzerland). The samples were dissolved in CDCl 3. The chemical shifts (δ) were calibrated concerning TMS. All 1D spectra were acquired with 32K data points. Typical acquisition parameters for the 1 H NMR experiments were as follows: acquisition time 1.58 s, spectral width 10330 Hz, pulse width 3.5 μs (flip angle≈30 ◦), relaxation delay 1s, and number of scans 32.

III. TRAILS CONDUCTED

a) *Diesel and Gasoline Trial*

i. *Method I*

Control – Each vehicle's fuel tank was filled with a specific brand and quantity of fuel and tested on different loads and road conditions. The specific fuel consumption (SFC), exhaust smoke, and other emissions were all recorded.

Trials – The protocol was the same as that of control, including the same vehicle. However, after filling with fuel before capping, MIRGA was sprayed into the tank via its mouth (then the tank was capped). The number of sprayings corresponding to the fuel was based on previous trial and error. For two and three-wheelers of below 20 liters of fuel - 1 spray for every 4 liters; for cars and SUVs of below 100 liters – 1 spray for every 10 liters; for heavy vehicles of above 100 liters – 1 spray for every 14 liters. The number of sprayings also depends on the engine model; usually, the estimated number may vary by one or two sprayings.

ii. *Method II*

The same protocol as in Method I was followed in 35 and 40 table-mounted various brands of diesel and gasoline engines at laboratories and academic institutions, respectively.

b) *Kerosene Trial*

i. *Method I*

Each equipment's kerosene tank was filled with a specific brand and quantity of kerosene, and then it ran until the kerosene was exhausted and the running time was recorded (control group). For trials, after filling the same tank with the same brand and quantity of kerosene, MIRGA was sprayed into the tank via its mouth, and the same methods as the control were followed. The running times of control and trial were compared. The number of sprayings is as follows:

2 litres - 1 spray
4-5 litres - 2 sprays
5-7 litres - 3 sprays
7-10 litres - 4 sprays

ii. *Method II*

The same method was used in 12 table-mounted kerosene engines in labs and academic institutions.

c) *Electricity Trial*

Control: The power generator was connected to a bottle containing 100 ml of gasoline and ran until it shut down automatically.

Trials: The same power generator was connected to the same bottle containing 100 ml of 1 MIRGA-sprayed gasoline and ran until it automatically stopped (first trial). Like this, in the second trial, 2 sprayings of 100 ml of gasoline in the same bottle ran until they automatically stopped. Then, in the third trial, 3 sprayings of 100 ml of gasoline in the same bottle were run until it automatically stopped.

In control and trials, time of running, power output, watt-hour (Wh), and kilowatt-hours (kWh) were calculated.

Though we used a variety of branded thermal (gasoline) power generators, the one that generated 28% more electricity (model Z 36Z RO; model name EP1000; type RD) is discussed here. A 200-watt bulb was the load given to this generator. The marketed gasoline (petrol) was used as a thermal power source. For each control and trial study, the same brand and source of gasoline were used, i.e., for every trial (1 control and 3 trials), 5 liters of gasoline were kept as the source.

d) *LPG Trial*

i. *Method I – Field trial*

This method was tested for almost 5 years using nearly 800 LPG domestic cylinders in houses, hostels, hotels, and mass kitchens.

Control: A new domestic LPG cylinder was connected to a stove, the regulator knob was kept in "ON" mode, gas was lit, and then the burning flame color, density, height, and calorific value were all measured. It was then left for the consumer's routine use.

Trial: A domestic LPG cylinder was connected to a stove, and the same parameters as the control were measured. While the flame was burning, MIRGA was sprayed continuously 6 times around the cylinder from a distance of 0.25-0.50 m. Then, burning flame color, density, height, and calorific value were measured, and it was then left for consumers' routine use. The control and trial cylinders' performance parameters were recorded and compared.

During our study, we increased the spraying number incrementally from 1 to 20. The trails were repeated several times, and 6 sprayings were found to be optimal for 14.2 kg and 9 sprayings for 19.5 kg LPG capacity cylinders.

i. *Method II – Laboratory trial*

A non-sprayed (control) and 6 time-sprayed LPG cylinders (trials of same brand and weight) were simultaneously lit, and the regulator knobs were kept in ON mode and let to continuously burn until gas exhausted and flames were lost. During burning, the flames' parameters were recorded. This was repeated 6 times with 12 cylinders from the same batch. The temperatures of small and large flames before and after spraying were also measured and compared.

e) *Instrumentation Sampling Technique*

To identify the chemical changes happening for every MIRGA spray, various instrumentations were performed. For this purpose, 4 samples of diesel and gasoline each 100 ml were taken. One formed a non-sprayed control; the other 3 trial samples correspondingly received 1, 2, and 3 sprayings. For kerosene, 5 samples were taken: one non-sprayed control and the other 4 trial samples correspondingly received 1, 2, 3, and 4 sprayings.

IV. RESULTS

a) *Diesel and Gasoline*

Table 1 and 2 respectively shows that the MIRGA irradiated diesel and gasoline has resulted in significantly reduced consumption and exhaust emissions besides reducing engine noise and smooth running within 5 minutes of on the road.

Table 1: Consumption and Emission Data – Diesel

Sl. No.	Exhaust	Result
1	Consumption	30-50 % reduced
2	CO	20-61% reduced
3	CO_2	1-29% reduced, in some vehicles increased
4	NOx	15-60% reduced
5	Oxygen	0.5-62% increase. In some vehicles, both CO_2 and O_2 emissions were found to increase.
6	HC	2-59% reduced, but in some vehicles increased

Table 2: Consumption and Emission Data – Gasoline

Sl. No.	Exhaust	Result
1	Consumption	12-58% reduced
2	CO	12-68% reduced
3	CO_2	1-29% reduced
4	NOx	2-23% reduced
5	Oxygen	2-52% increased
6	HC	5-65% reduced, but some engines showed a slight increase
8	RPM	16% increased, some engines showed a slight decrease

b) *Kerosene*

Depending on the instrument model, 35-80% consumption is reduced.

c) *Electricity*

Table 3: Comparison of Power Generation using Control and MIRGA Treated Gasoline

Before spraying (Control) Time of Running: 17.22 min Fuel consumed: 100 ml	After 1 spraying (Trial) Time of Running: 22.08 min Fuel consumed: 100 ml
Power output: P = V * I *(Power = voltage * current)* P = 200 watts, V = 230, I = 0.87 A 200 W = 230V * 0.87 A *Wh = P * H (Watt hours = Power * Hours)* P = 200 watts, H = 0.287 Hrs (17.22 min) = 200 * 0.287 ***Wh = 57.4 / 100ml*** For 1 Litre = 574 Wh (i.e) 0.574 kWh for one liter of petrol.	***Power output:*** P = V * I *(Power = voltage * current)* P = 200 watts, V = 230, I = 0.87 A 200 W = 230 V * 0.87 A *Wh = P * H (Watt hours = Power * Hours)* P = 200 watts, H = 0.287 Hrs (22.08 min) = 200 * 0.368 ***Wh = 73.6 / 100ml*** For 1 Litre = 736 Wh (i.e) 0.736 kWh for one liter of Petrol.

Gasoline (control) = 0.574 kWh power generation
MIRGA treated Gasoline = 0.736 kWh power generation
Difference = 0.162 kWh power generation

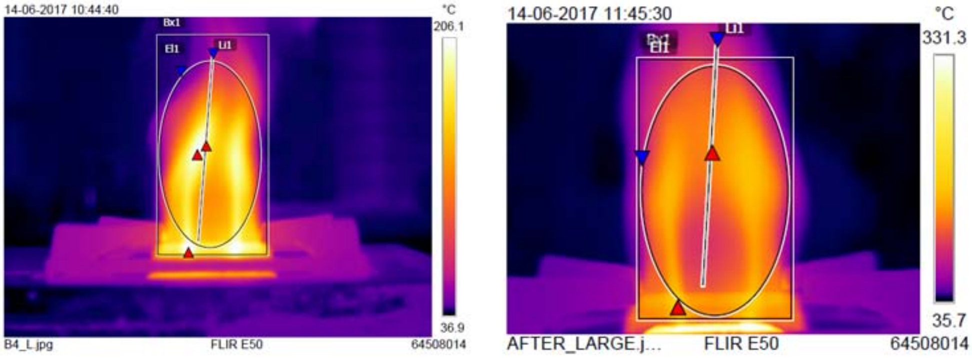
Table 3 illustrates that the 1 sprayed gasoline produced 28% more electricity compared to the control. The 2 and 3 sprayed samples generated less than 28% electricity.

Tables 1, 2, and 3 demonstrated the benefits of 2-6 µm mid-IR on liquid fuels.

d) For LPG

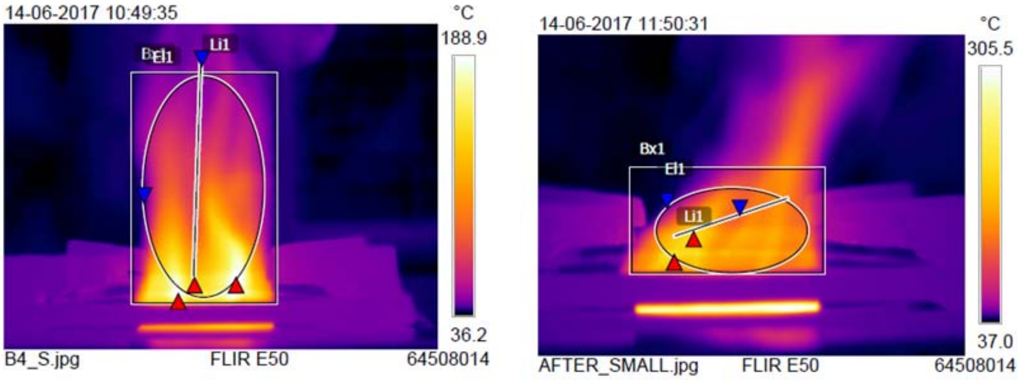
In trial cylinders after 6 sprayings, between 7 and 60 seconds the flame became dense, rose in height, and turned completely yellow (indication of MIRGA's action on LPG). This burning phenomenon was found to be not soot radiation emission because this occurred only when spraying was done on the trialed cylinders (some control and trial cylinders during burning showed very mild occasional soot radiation emission). After use, when cylinders are exhausted the duration of burning is calculated and compared between trial and control. In the trailed cylinders 28-35% reduction in LPG fuel consumption was recorded (i.e. approximately a 30% utility time increase) with no apparent pollution.

Six MIRGA sprayings given once were enough until a cylinder was exhausted and effects were found to have retained in LPG for 30-34 months (depending on the brand).



Before spray **After spray**

Fig. 4a: LPG Trial with Large-Sized Burner



Before spray **After spray**

Fig. 4b: LPG Trial with Small-Sized Burner

Table 4: Burner Trial Result Comparison

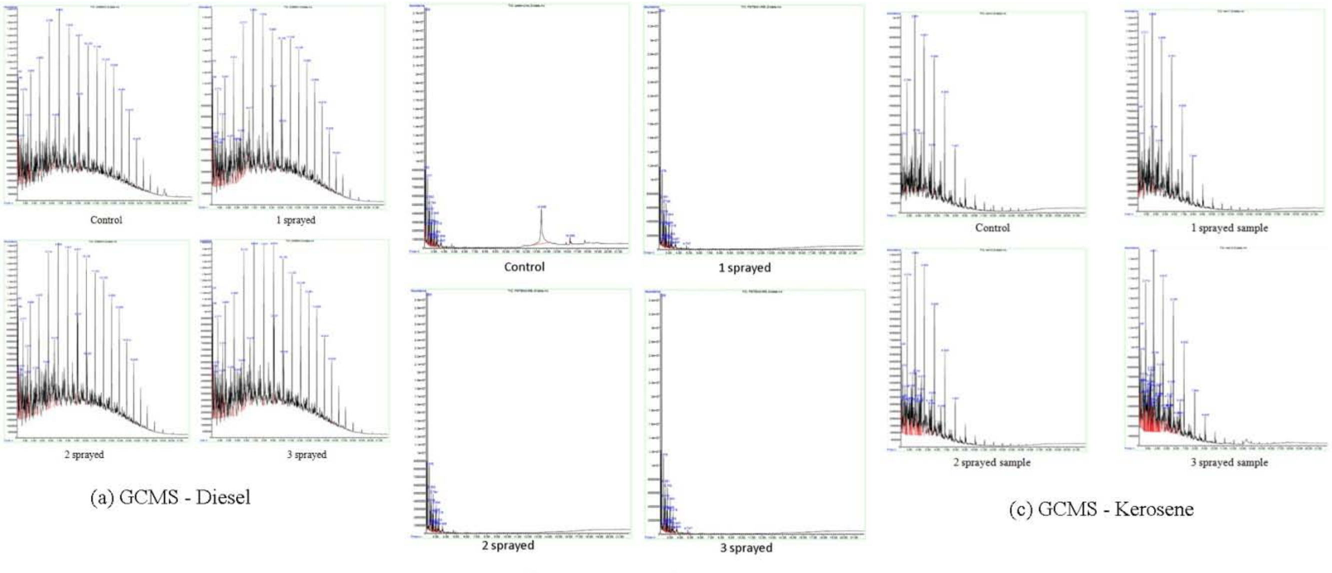
Burner type	B x 1° C				EL 1 (Elliptical flame) °C				Li 1 (Linear flame) °C				Whole flame temperature °C			
	Bs	As	Df	Imp%	Bs	As	Df	Imp%	Bs	As	Df	Imp%	Bs	As	Df	Imp%
Large sized burner	219	220	1	0.45	144	168	24	16	158	155	-3	-2	206	331	125	60
Small sized burner	202	234	32	15	99	171	72	73	84	177	93	110	188	305	117	62

Bs *– Before spray,* ***As*** *– After spray,* ***Df*** *– difference,* ***Imp*** *– Improvement percent*

From Table 4, compared to the non-sprayed cylinder, the sprayed LPG cylinder's large-sized burner flame temperature was found to be increased viz., elliptical flame 16% and whole flame 60%, and linear flame -2%. (Fig. 4a).

Compared to the non-sprayed cylinder, the sprayed LPG cylinder's small-sized burner flame temperature was found to be increased viz., elliptical flame 73%, linear flame 110%, and whole flame 62%. (Fig. 4b).

For the LPG field trial, please view: https://drive.google.com/file/d/1r-no1OfoxaOD_VV7fvuscJ5Yj-aGXP_n/view

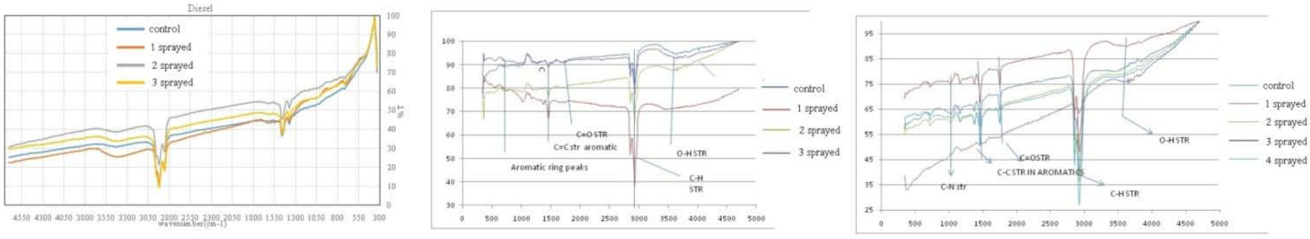


(a) GCMS - Diesel

(b) GCMS - Gasoline

(c) GCMS - Kerosene

Fig. 5: GCMS Spectra (a) Diesel, (b) Gasoline, (c) Kerosene

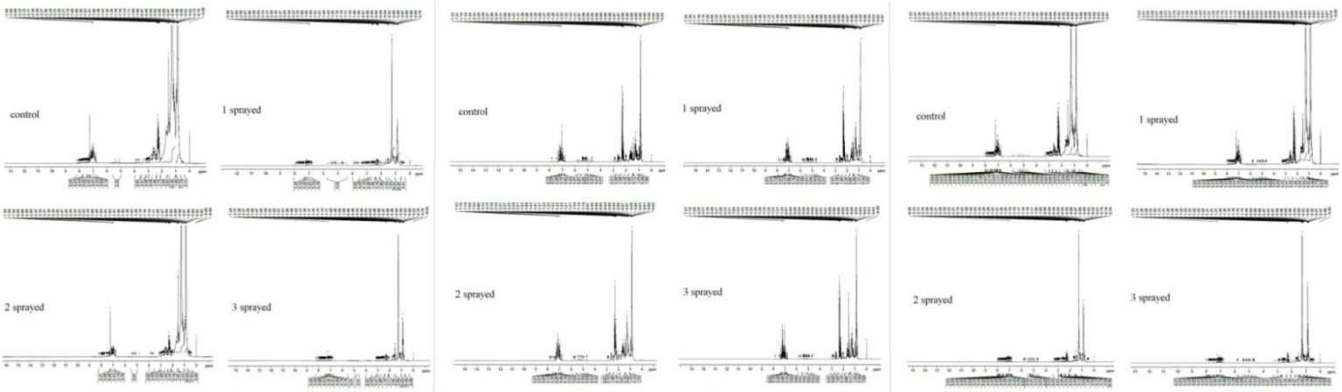


(a) FTIR - Diesel

(b) FTIR - Gasoline

(c) FTIR - Kerosene

Fig. 6: FTIR Spectra (a) Diesel, (b) Gasoline, (c) Kerosene



(a) NMR - Diesel

(b) NMR - Gasoline

(c) NMR - Kerosene

Fig. 7: 1H-NMR Spectra (a) Diesel, (b) Gasoline, (c) Kerosene

V. INSTRUMENTATION RESULTS

(Raw data files of instrumentations for Diesel, Gasoline and Kerosene presented in Supplementary data D1).

a) GC-MS

i. GCMS – diesel

The control sample contained typical hydrocarbon components like Decane, Undecane, Tridecane, Tetradecane, Pentadecane, Hexadecane, Heptadecane, Octadecane, Nonadecane, Eicosane, Heneicosane, and Tetracosane. These peaks (with comparatively low content) were also presented in all the sprayed samples suggesting that the diesel samples have not changed their principle components after spraying. However, each spraying has generated a new unique peak in each sample and is responsible for corresponding changes. One sprayed sample has shown a unique peak of Tridecane, 6-cyclohexyl, while 2 sprayed samples have shown Pentacosane as a unique peak, and 1-H-Indene, 2,3-dihydro-4,7-dimethyl was the unique peak for 3 sprayed samples. (Fig. 5a)

ii. GC-MS – gasoline

The control sample contains components like Benzene, 1-ethyl-2-methyl, Benzene, 1, 2, 3-trimethyl, Indane, o-cymene, and Oleic acid as major products. The peak of Benzene, 1, 2, 3-trimethyl (high in content) was also presented in all the sprayed samples suggesting that the petrol samples have undergone considerable changes its components after spraying. Additionally, spraying has generated several new unique peaks Naphthalene, 1-methyl, Indane, 1-methyl, etc. in a respective sample and is responsible for corresponding changes. The 1 sprayed sample has shown an increase in the peak of O-Cymene, Indane, etc., while 2 sprayed samples showed Naphthalene as a unique peak and Naphthalene, 1-methyl, and Indane, 1-methyl were unique peaks for 3 sprayed samples. (Fig. 5b)

iii. GC-MS – Kerosene

The kerosene control sample contained typical components like Decane derivative, Undecane, Dodecane, Nanone derivative, Triodecane, Tetradecane, Pentdecane, Hexdecane, etc. All these peaks (with comparatively low and high content) were also presented in all the sprayed samples suggesting that the kerosene samples have undergone considerable changes in their components after spraying. Additionally, all the sprayings have generated several new unique peaks like Decane, 3-methyl, Tridecane, 7-methyl, 1-hexadecanol, and 1-hexadecanolin a respective sample and could be responsible for corresponding changes. The 1 sprayed sample showed unique of Dodecane and Tridecane, 7-methyl-while 2 sprayed sample showed a higher peak of Decane, 2-methyl and Undecane, 2,6-dimethyl than control and Decane, 3,6-dimethyl was a unique peak in 3 sprayed sample. (Fig. 5c)

b) FTIR

i. FTIR – Diesel

The main bands of the spectra originated from saturated, aliphatic compounds as they represent most of the molecules present in the sample. These bands (the ones between 3000-2800 cm^{-1}, and the ones between 1450-1350 cm^{-1}) show very similar transmittance values in control, 1, and 3 sprayed samples, pointing to comparable concentrations. In 2 sprayed samples, those bands show a significantly higher transmittance (lower absorption), indicative of a lower concentration of the molecules contributing to them. Regarding the transmittance of the baseline, behind which some bands coming from minor components are present, the absorption (concentration) decreases following this order: 1 sprayed > control > 3 sprayed > 2 sprayed. This observation indicates that 1 spraying causes an augmentation in the concentration of some components of the sample. However, upon successive sprayings a reduction of the concentration takes place (with 2 spraying) and, somehow, concentration is partially recovered (with 3 sprayings). (Fig. 6a)

Since diesel is a mixture of many different hydrocarbons, changes observed in the properties of the samples are related to variations taking place in the ratio of those hydrocarbons. For the same kind of hydrocarbon, a higher number of carbon atoms leads to a higher heating value. The effect of mid-IR spraying favors the loss of the more volatile compounds (this is, those with lower molecular mass and therefore lower number of carbons). So, as the sample is more and more sprayed, the concentration of hydrocarbons with a higher number of carbons increases, and the heating value of the sample rises leading to a lower consumption. For the same reason, these changes in composition could improve combustion and thus reduce the pollutants produced as suggested before.

ii. FTIR – Gasoline

A broad peak due to O-H stretching at 3400-3600 cm^{-1} is observed. This indicates the presence of the phenolic group. C-H stretching at 2924 cm^{-1} due to –CH_2, CH_3 of saturated hydrocarbon. The peak at 1700 cm^{-1} is due to C=O stretching which overlaps in the control sample and 3 sprayed samples. The peak at 1465 cm^{-1} is due to C=C str in the aromatic ring. The peak at 748 cm^{-1} is due to aromatic rings which are more intense in 1 and 2 sprayed samples than control. The increased intensity of the C=C stretching at 1465 cm^{-1} in sample 1 sprayed and 2 sprayed samples, and increased intensity of –C-H stretching in all the sprayed samples. Compared to the control indicates that photochemical transformation is happening and polycyclic aromatic hydrocarbons are formed from benzene derivatives. The higher intensity of polycyclic aromatic hydrocarbon makes the sprayed sample more homogeneous and better quality compared to the control. (Fig. 6b)

iii. *FTIR – Kerosene*

There is a broad peak due to O-H stretching at 3400-3600 cm^{-1} which indicates the presence of the phenolic group. The peak intensity due to O-H str is decreased in 2, 3, and 4 sprayed samples in comparison to control. However, the peak intensity is higher in 1 sprayed sample. The peak at 2854.64 cm^{-1}, 2924 $cm^{-1,}$ and 2954 cm^{-1} is due to C-H stretching of –CH_2, CH_3 of saturated hydrocarbons. The intensity of this peak is higher in 4 sprayed samples and is decreased in 3 sprayed samples. The peak at 1751 cm^{-1} is due to C=O stretching which disappears in 3 sprayed samples. The peak at 1465 cm^{-1} is due to C-C str in the aromatic ring which is not present in 3 sprayed samples. The peak at 1188 cm^{-1} is due to C-O str being found in all except 3 sprayed samples. This peak overlaps in 2 and 4 sprayed samples. The peak at 748 cm^{-1} is removed in 3 sprayed samples which indicates the amount of unsaturation is decreased after 3 sprayings. (Fig. 6c)

The increased intensity of –C-H stretching in all samples. Compared to control indicates that photochemical transformation[17] is happening and mono-substituted and para-substituted benzene molecules are converted to polycyclic aromatic hydrocarbons.

c) *Proton NMR Spectra*

i. *Proton NMR – Diesel*

Significant variations in the integral values of some regions are observed, pointing to changes in the concentration of some chemical species. If the most volatile compounds are reduced upon MIRGA spraying, the signals originated by them in the NMR spectra will have a lower integral value. The most volatile compounds are expected to be aliphatic molecules with a low number of carbons and thus their signals will be located between 0.3 and 2.1 ppm. Unfortunately, it is difficult to observe a clear diminution of the integral value, because of the high overlapping. The high number of present species causes that in every region signals of very diverse molecules are present (Fig. 7a). For example, in the aliphatic region not only the signals from simple aliphatic molecules present but also aliphatic moieties from more complex hydrocarbons are also there. For this reason, it is a complex task to drag a clear correlation between changes observed in sample properties and variations in the integration of NMR signals. However, those changes are directly related to changes in the concentration of the present chemical species and undoubtedly this has an impact on the proportion between diesel components that ultimately affects its properties.

ii. *Proton NMR – Gasoline*

The 1H NMR spectra reveal the presence of a three-proton singlet at δ2.2 for a CH_3 group on an aromatic ring, two peaks each of three-proton intensity at δ0.8-0.9 for CH_3. It also shows a group at δ1.2. The CH_3 group resonances are attributed to the different CH_3 groups. To distinguish between the 3 subsamples, the peak integral of each sample was normalized. The number of CH_3 aliphatic groups is the same in all samples. However, there is a reduction in the number of CH_3 aromatic upon MRGA spraying i.e. 50% reduction from 4 in the Control to 2 in all the sprayed samples (Fig. 7b). This suggests changes in the aromatic component which could be responsible for the reduced pollutant in gasoline.

iii. *Proton NMR – Kerosene*

The 1H NMR spectra reveal the presence of a three-proton singlet for the CH_3 group in aromatic rings, and the peak of three-proton intensity at δ0.9 for CH_3. It also shows the CH_2 group at δ1.2. The CH_3 group resonances are attributed to the different CH_3 groups. In order to distinguish between the 3 sub-samples, the peak integral of each sample was normalized. The number of CH_3 aliphatic groups is the same in all samples. However, there is a clear reduction in the number of CH_3 aromatic upon MIRGA spraying (reduced significantly from 8 in the Control sample to 1 in all the sprayed samples) (Fig. 7c). This suggests changes in the aromatic component which could be responsible for the reduced pollutant in the kerosene.

Compared with control data, all the instrumentation data suggested that MIRGA spraying has altered chemical bonding, chemical composition, configuration, and compound transformation leading to alteration in molecular characteristics.

VI. BENEFITS AND FUTURE PROSPECTS OF MIRGA

1. An average of 30% of the natural resource has been demonstrated to be saved, and associated pollution is reduced.
2. Clear restoration of a cleaner environment and health issues reduction.
3. Efficient engine functioning and found to operate smoothly.
4. Old motor engines performed nearly as well as recent models in fuel consumption and toxic emission reduction.
5. One spraying series is enough for an entire fuel tank / LPG cylinder until exhausted.
6. Increased electricity generation, enhancing economic efficiency.
7. More utility days of LPG hence economy.

VII. DISCUSSION

a) *Action of MIRGA emitted 2-6 µm mid-IR on Fuels*

MIRGA was designed to generate 2-6 µm mid-IR and alter targets chemical bond parameters thereby to produce more beneficial effects *Umakanthan et al., 2022a; Umakanthan et al., 2022b, Umakanthan T, Mathi M, 2023c) (detailed discussion presented in Supplementary Text T1)*. In this research, we observed that MIRGA spraying in diesel has caused chemical bond changes, and increased hydrocarbon concentration, thereby improving combustion, and hence reducing pollution. In gasoline, MIRGA spraying has caused O-H, C=C, C=O, and C-H chemical bond stretchings, photodissociation, photochemical transformation, and formation of polycyclic aromatic hydrocarbons from benzene derivatives, more homogenation leading to better quality compared to the non-sprayed control. With just a little experience, a driver can identify his vehicle's spraying number requirement concerning fuel quantity.

The composition/ properties of the hydrocarbons determine the performance and emission of the internal combustion engine. Fuel additives influence the properties of the fuels hence additive research dynamic. Gaseous, liquid, and solid (Metal and carbon-based) additives are now in use. Using these additives in diesel and gasoline engines various studies were done as cited by *(Abdellatief et al., 2021; Daud et al., 2022)*. They used B20, diesel, biodiesel, diesel ethanol, diesel methanol, etc. in diesel engines; and bio ethanol, prenol, furan mixture, dimate (isohexane), isooctene (di-isobutylene) in gasoline engine. And full load with different RPM, constant speed, and different blends with various load were employed. They studied the performance viz power, BTE, BSFC, and torque. The net emission result was inconsistent with their limitations. Among all additives tried to date Graphene nanoplatelets additive is found to be promising but this research is still insufficient *(Daud et al., 2022)* engine hybridization *(Schifter et al., 2020)* biofuel, electric vehicle *(Pattanaik et al., 2017 and Cano et al., 2018)* studies also showed inconsistent result and limitations. Turbocharging is a better technology but it has increased the demands on the detonation resistance of fuel *(Alabas et al., 2020).*

Comparing these studies, MIRGA techniques also seem to be favorable hence may be placed as one of the fuel additive. It also seems that except for MIRGA technology no literature or techniques are available to improve the electricity generation and LPG utility days. MIRGA sprayer is user-friendly and economical. A MIRGA sprayer that emits 300 sprayings approximately costs USD 0.3.

VIII. CONCLUSION

In summary, we have shown that applying 2-6 µm wavelength range mid-infrared rays to liquid and gaseous fuels. The mid-IR caused photode gradation of the fuels. There by considerably lower their overall consumption and simultaneously associated pollution at affordable cost. An average of 30% of the natural resource has been demonstrated to be saved. Furthermore, irradiated gasoline generated more (28%) electricity. This technology is demonstrated to be safe and economical for practical use, as well as beneficial to the environment and reduces human health risks. In the future unique features of MIRGA technology and research on similar resources may shed more light on potential avenues for manipulating fuels more desirable.

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Author Contributions

Umakanthan: Conceptualization, Methodology, Supervision, Validation, Funding.

Madhu Mathi: Investigation, Data curation, Visualization, Writing - Original draft preparation.

Umadevi, Sivaramakrishnan: Project administration, Resources, Writing- Reviewing and Editing.

Data and Materials Availability

All data is available in the manuscript and supplementary materials.

Conflict of 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 *(under-patent no.: 401387)* which is a major material employed in this study.

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Supplementary data D1: Raw data files of instrumentations for Diesel, Gasoline and Kerosene https://drive.google.com/open?id=1335uu4v87jy7LE2Jv3VxkoqbIFQ0V6Qt.

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

Supplementary Text T1: 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 photo dissociation 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.

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