International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 3 Volume No.7 May - June – 2023
DOI:10.46647/ijetms.2023.v07i03.011 ISSN: 2581-4621

A Study on the Gamma-ray Attenuation coefficient Parameters for Potassium Carbonate

Sharique S. Shaikh[1] Suryakant B. Borul[2] and Shahebaz Sakhawat Khan[3]
[1]*Department of Physics, Late Ku. Durga K. Banmeru Science College, Lonar Pin 443302 Dist Buldana M.S.*
[2]*Department of Chemistry, Late Ku. Durga K. Banmeru Science College, Lonar Pin 443302 Dist Buldana M.S.*
[3]*Department of Physics, Maulana Azad College, Rauza Bagh Aurangabad, M.S.*
Corresponding Author Orcid ID: 0009-0001-2907-1748

ABSTRACT
The linear attenuation coefficient (LAC) and mass attenuation coefficient (MAC) are most important while studying of radiation, radio-isotopes in dosimentry and irradiation of materials. In the present work to calculate linear attenuation coefficient (LAC) and mass attenuation coefficient (MAC) values of different salts samples by using Gamma-ray spectrometry with Photo-Multiplier Tube (PMT) and Multi-Channel Analyzer (MCA). The 0.123, 0.511, 0.662, 1.17, 1.28 and 1.33MeV gamma energy rays used for the experiment in the interaction of Potassium carbonate salt samples and compared the Mass attenuation coefficient (MAC) values of salt samples. The obtained gamma-ray spectra were analyzed using computer software.
KEY WORDS:-Gamma-ray attenuation parameters, Gamma-ray spectrometry, Potassium Carbonate.

1. Introduction

The linear attenuation and mass attenuation coefficient of elements, molecules and materials are widely used in space physics, dosimetry, and plasma physics and in the field of radiation physics. The technology developed day by day, the gamma rays are used in many fields, like medicine, food preservation and with their measurement techniques are developed but we find these measurements can be made with still simpler method. The study of absorption of gamma radiations in the material and these are used for study of biological importance.

There are different measurement techniques to measure them. As the technology developed now a day, the gamma rays are used in many areas such as food preservation and medicine and with their measurement techniques are developed. This method is developed from single element mass attenuation coefficient of gamma rays to a mixture that is solute and solvent. In 1977 Hubbel *et al.*, has reported the mass attenuation coefficient for hydrogen, carbon, nitrogen and oxygen at low gamma energy, according to his μ/ρ of these elements using butanol, pentanol, N-N dimethyl acetate and acetone and the other elements i.e. Na, K, Mg. Teli *et al.*, 1994 have measured the attenuation coefficient of 123Kev gamma radiations by dilute solution of sodium chloride. Dongarge et al., 2010 proposed the linear attenuation coefficient for gamma a rays for ammonium sulfate salt by aqueous solution method 1.28 MeV gamma ray energy. Hubbel has calculated mass attenuation coefficient for 92 elements for hydrogen to Uranium and some compounds from photon energies 1 KeV to 20 MeV.

2. Method and Materials

In this study to calculate gamma ray attenuation parameters, some salt samples were by using gamma-ray spectrometry with Photo-Multiplier Tube (PMT) and Multi-Channel Analyzer (MCA). The interaction of these with matter has various effect like light pulses or chemical changes in materials which is to be detected by detector. First the gamma rays are passed through empty container reaching the detector. The spectrum is obtained for 1800 sec. using MCA which gives plot of channel number Vs counts. The block diagram of gamma-ray spectrometry with Multi-Channel Analyzer (MCA) is

DOI:10.46647/ijetms.2023.v07i03.011 ISSN: 2581-4621

as shown in the fig.1. The spectrometer comprises scintillator material coupled with photomultiplier tube (PMT) and preamplifier housed in scintillation head. The signal collected from PMT are amplified and digitalized for further processing in Multi-Channel Analyzer (MCA). For gamma ray spectrometry, inorganic crystal of thallium doped Sodium iodide [NaI(Tl)] was used in scintillation detector. The NaI(Tl) was the most extensively used as it has very scintillation efficiency and available in single crystal polycrystalline forms a wide variety of size and geometries. It has maximum light yield is in the range 20^oC to 60^oC which normal ambient temperature.

The experiment for the measurement of mass attenuation coefficient and linear attenuation coefficient carried out of aqueous solution of Potassium Carbonate compound by a gamma transmission in narrow beam geometry. The measurement of mass attenuation coefficient and linear attenuation coefficient of Potassium m Carbonate at different gamma energies range as 0.123 to 1.33MeV at different amount of concentrations of salt ranges 6.9774gm to 15.9391gm. The experimental arrangement for measuring mass attenuation coefficient and linear attenuation coefficient of the compound is as shown in the fig.2. The total linear attenuation coefficient μ/p (cm^{-1}) and mass attenuation coefficient μ/p (cm^2/gm) of the absorber are related by the standard exponential law.

$I=Io\ e^{-\mu h}$ and

$I=Io \exp [\mu / \rho^{(ph)}]$

Since Io, I are proportional to the gross area under the photo-peak of interest. A cylindrical container of internal radius r cm, the density of the solution of mass m and height h cm in the container is given by $p=m / \pi r^2$ therefore the equation as-

$\mathrm{I} = Io \exp[\frac{\mu}{\rho} + \frac{m}{\pi r2}]$

From above equation (μ / ρ)' as-

$$\left(\frac{\pi}{\rho}\right)' = \frac{\pi r^2}{m}\ In[\frac{Io}{I})$$

By using this graphical equation calculate the value $\frac{\pi}{\rho}$ from slope.

The gross area of selected region of interest in accumulated spectrum for 1800 sec was used for calculations. The data of measured linear attenuation coefficient of Magnesium Carbonate at different gamma energies range as 0.123, 0.511, 0.662, 1.17, 1.28 and 1.33MeV at different concentration range 6.9774 gm to 15.9391gm as shown in table 1, 2, 3,4,5 and 6.

The block diagram of gamma-ray spectrometry with Multi-Channel Analyzer (MCA) is as shown in the fig.1.

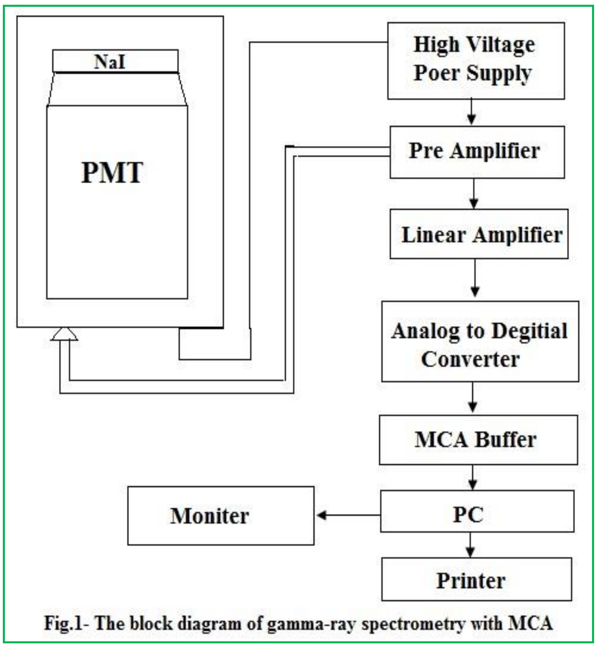

Fig.1- The block diagram of gamma-ray spectrometry with MCA

International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 3 Volume No.7 May - June – 2023
DOI:10.46647/ijetms.2023.v07i03.011 ISSN: 2581-4621

The experimental arrangement for measuring mass attenuation coefficient and linear attenuation coefficient of the compound is as shown in the fig.2.

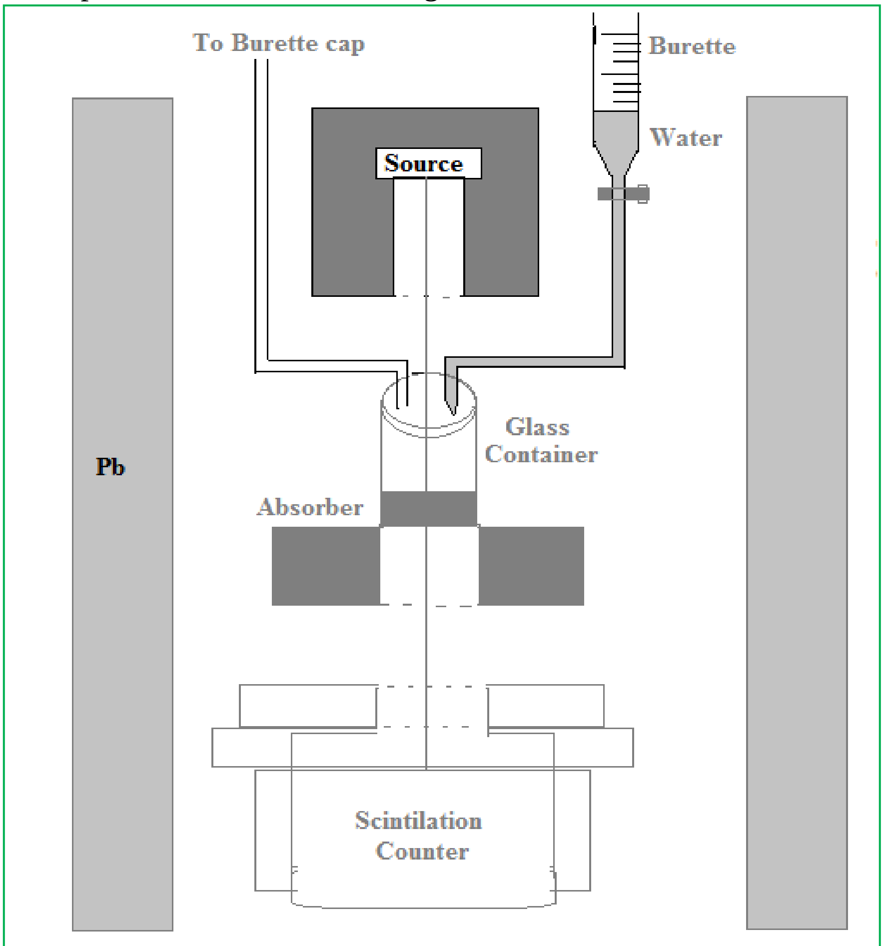

Fig. 2- Experimental narrow beam geometry setup for measuring gamma absorption coefficient for liquids and salts

3. Results and Discussion

The experimental observations were made for the measurement of measured linear attenuation coefficient and mass attenuation coefficient of Magnesium Carbonate. The gross area of selected region of interest in accumulated spectrum for 1800 sec was used for calculations. The mass attenuation coefficient $(\frac{\mu}{\rho})$ was estimated from the linear attenuation coefficient of Magnesium Carbonate. The data of measured linear attenuation coefficient of Magnesium Carbonate at different gamma energies range as 0.123, 0.511, 0.662, 1.17, 1.28 and 1.33MeV at different concentration range 6.9774 gm to 15.9391gm as shown in table 1, 2, 3,4,5 and 6. The percent deviations between experimental and theoretical values of mass attenuation coefficient $(\frac{\mu}{\rho})$ are showing good agreement, as shown in table7.

The measured values of linear attenuation coefficient μc (cm^{-1}) at different gamma energies range as 0.123, 0.511, 0.662, 1.17, 1.28 and 1.33MeV.

Table-1- Gamma ray energy 0.123 MeV **Mass of Comp.= 2gm**

m(gm) $m=m_c+m_w$	Io, I 1800 Sec	Ln(Io/I)	m_c / m x-axis	$(\frac{\mu}{\rho})$ y-axis
0.0000	11220			
6.9774	8555	0.27118	0.28660	0.16191

International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 3 Volume No.7 May - June – 2023
DOI:10.46647/ijetms.2023.v07i03.011 ISSN: 2581-4621

7.9710	8289	0.30277	0.25082	15820
8.9693	7957	0.34365	0.22297	0.15962
9.9652	7658	0.38195	0.20070	0.15969
10.9611	7362	0.42137	0.18247	0.16017
11.9572	7139	0.45213	0.16727	0.15754
12.9521	6804	0.50019	0.15441	0.16089
13.9430	6489	0.54759	0.14339	0.16357
14.9447	6378	0.56484	0.13384	0.15748
15.9391	6197	0.59363	0.12548	0.15517

Table-2- Gamma ray energy 0.511 MeV

m(gm) $m=m_c+m_w$	Io, I 1800 Sec	Ln(Io/I)	m_c / m x-axis	$(\frac{\mu}{\rho})$ y-axis
0.0000	27543			
6.9774	23599	0.15454	0.28662	0.09227
7.9710	23168	0.17298	0.25091	0.09041
8.9693	22476	0.20330	0.2298	0.09443
9.9652	22183	0.21642	0.20070	0.09049
10.9611	21486	0.24835	0.18242	0.09437
11.9572	21227	0.26047	0.1671\24	0.09075
12.9521	20707	0.28528	0.15442	0.09177
13.9430	20148	0.3264	0.14339	0.09339
14.9447	19576	0.34144	0.13384	0.09520
15.9391	19378	0.35161	0.12548	0.09191

Table-3- Gamma ray energy 0.662 MeV

m(gm) $m=m_c+m_w$	Io, I 1800 Sec	Ln(Io/I)	m_c / m x-axis	$(\frac{\mu}{\rho})$ y-axis
0.0000	20765			
6.9774	18077	0.13863	0.28665	0.08278
7.9710	17665	0.16168	0.25078	0.08447
8.9693	17368	0.17864	0.22299	0.08298
9.9652	17052	0.19700	0.20072	0.08237
10.9611	16704	0.21762	0.18247	0.80272
11.9572	19298	0.24223	0.16732	0.08443
12.9521	16038	0.25831	0.15441	0.08309
13.9430	15589	0.28370	0.14339	0.08565
14.9447	15287	0.30627	0.13385	0.08540
15.9391	15084	0.31863	0.12548	0.08355

Table-4- Gamma ray energy 1.17 MeV

m(gm) $m=m_c+m_w$	Io, I 1800 Sec	Ln(Io/I)	m_c / m x-axis	$(\frac{\mu}{\rho})$ y-axis
0.0000	20167			
6.9774	18138	0.10604	0.28668	0.06333
7.9710	17833	0.12300	0.25051	0.06426
8.9693	17689	0.13110	0.22299	0.06090
9.9652	17378	0.14884	0.20072	0.06224

International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 3 Volume No.7 May - June – 2023
DOI:10.46647/ijetms.2023.v07i03.011 ISSN: 2581-4621

10.9611	17125	0.16351	0.18246	0.06215
11.9572	16803	0.18249	0.16732	0.06361
12.9521	16434	0.20470	0.15440	0.06584
13.9430	16283	0.21368	0.14339	0.06383
14.9447	16004	0.23121	0.13385	0.06447
15.9391	15864	0.24000	0.12548	0.06273

Table-5- Gamma ray energy 1.28 MeV

m(gm) $m=m_c+m_w$	Io, I 1800 Sec	Ln(Io/I)	m_c / m x-axis	$(\frac{\mu}{\rho})$ y-axis
0.0000	11567			
6.9774	10424	0.10405	0.28668	0.06214
7.9710	10288	0.11718	0.25082	0.06123
8.9693	10165	0.12921	0.22304	0.06003
9.9652	10034	0.14218	0.20068	0.05944
10.9611	9828	0.16292	0.18245	0.06192
11.9572	9764	0.16945	0.16734	0.05907
12.9521	9534	0.19329	0.15441	0.06217
13.9430	9429	0.20437	0.14339	0.06105
14.9447	9226	0.22613	0.13385	0.06305
15.9391	9104	0.23944	0.12549	0.06359

Table-6- Gamma ray energy 1.33 MeV

m(gm) $m=m_c+m_w$	Io, I 1800 Sec	Ln(Io/I)	m_c / m x-axis	$(\frac{\mu}{\rho})$ y-axis
0.0000	10896			
6.9774	9832	0.10275	0.28671	0.06137
7.9710	9769	0.10918	0.25088	0.05706
8.9693	9576	0.12914	0.22304	0.06000
9.9652	9477	0.13953	0.20072	0.05834
10.9611	9322	0.15602	0.18245	0.05930
11.9572	9201	0.16821	0.16734	0.05864
12.9521	9028	0.18806	0.15441	0.06049
13.9430	8936	0.19831	0.14439	0.05924
14.9447	8724	0.22232	0.13384	0.06199
15.9391	8639	0.22321	0.12548	0.06067

The percent deviations between experimental and theoretical values of mass attenuation coefficient $(\frac{\mu}{\rho})$ are follows

Table-7- Mass attenuation coefficient for Magnesium Carbonate.

Energy (MeV)	Experimental values	Theoretical Values	% Deviation
0.1230	0.18318	0.18917	3.17064
0.5110	0.08450	0.08451	0.01775
0.6620	0.07523	0.07520	-0.04122
1.1700	0.05708	0.05699	-0.15967
1.2800	0.05456	0.05447	0.17808
1.3300	0.05391	0.05349	-0.78701

International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 3 Volume No.7 May - June – 2023
DOI:10.46647/ijetms.2023.v07i03.011 ISSN: 2581-4621

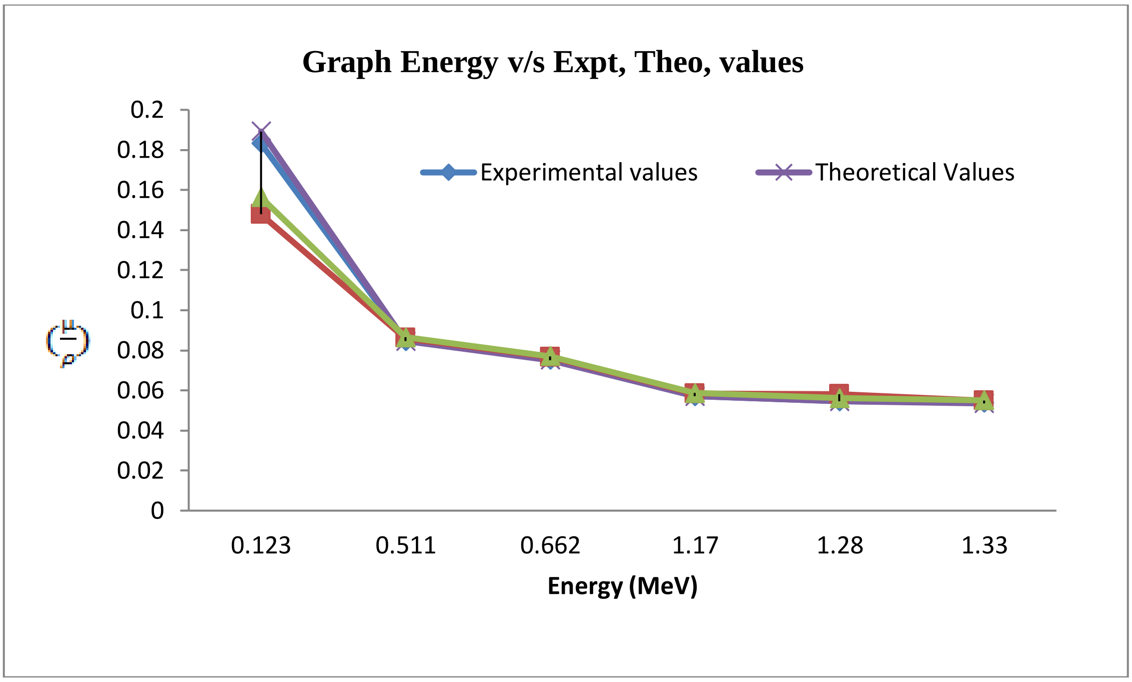

Fig.3- Graph of Energy V/S experimental and Theoretical values of $(\frac{\mu}{\rho})$ for Magnesium Carbonate

Conclusion

In the this research work experimental and theoretical measurement of linear and mass attenuation coefficient of Potassium Carbonate at different gamma energies range as 0.123, 0.511, 0.662, 1.17, 1.28 and 1.33MeV. The validity of the exponential absorption law for gamma radiation in solution, also as in solids and provide a new method for the determination of linear attenuation coefficient µc (cm^{-1}) and mass attenuation coefficient $(\frac{\mu}{\rho})$ for soluble substance. The method used is simple and avoids the need of preparation of pure crystalline compound for experiment thereby saving time and expenditure. The results of this study give information about self attenuation correction factors. The attenuation coefficients are needed for different applications of radiation, e.g. dosimetry, radiography, tomography in industrial, agricultural and medical areas in science, technology, human health etc.

Acknowledgment

The authors would like to thank Dr. C.S. Mahajan Sir for useful suggestions and comments.

Reference

1. Pravina P Pawar Gamma ray photon interaction studies of Cr in the energy range 10keV to 1500keV, 3(6):693-706, J. Chem. Pharm. Res. 2011.
2. S R Mitkar and S M Dongarge -To study the linear and mass attenuation coefficient of alcohol soluble compound for gamma rays at energy 662 KeV, 4(8):3944-3949. Journal of Chemical and Pharmaceutical Research. 2012.
3. R. Devi Priya, R. Sivaraj, Ajith Abraham, T. Pravin, P. Sivasankar and N. Anitha. "MultiObjective Particle Swarm Optimization Based Preprocessing of Multi-Class Extremely Imbalanced Datasets". International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems Vol. 30, No. 05, pp. 735-755 (2022). Doi: 10.1142/S0218488522500209
4. V.S. Rajashekhar; T. Pravin; K. Thiruppathi , "Control of a snake robot with 3R joint mechanism", International Journal of Mechanisms and Robotic Systems (IJMRS), Vol. 4, No. 3, 2018. Doi: 10.1504/IJMRS.2018.10017186

5. Minh Duc Ly; Que Nguyen Kieu Viet. "Improvement Productivity and Quality by Using Lean Six Sigma: A Case Study in Mechanical Manufacturing". International Research Journal on Advanced Science Hub, 4, 11, 2022, 251-266. doi: 10.47392/irjash.2022.066
6. Ragunath A; Poonam Syal. "Net Zero Energy Buildings Initiatives - A Review". International Research Journal on Advanced Science Hub, 4, 11, 2022, 267-271. doi: 10.47392/irjash.2022.067
7. Vo Ngoc Mai Anh; Hoang Kim Ngoc Anh; Vo Nhat Huy; Huynh Gia Huy; Minh Ly. "Improve Productivity and Quality Using Lean Six Sigma: A Case Study". International Research Journal on Advanced Science Hub, 5, 03, 2023, 71-83. doi: 10.47392/irjash.2023.016
8. Swathi Buragadda; Siva Kalyani Pendum V P; Dulla Krishna Kavya; Shaik Shaheda Khanam. "Multi Disease Classification System Based on Symptoms using The Blended Approach". International Research Journal on Advanced Science Hub, 5, 03, 2023, 84-90. doi: 10.47392/irjash.2023.017
9. Susanta Saha; Sohini Mondal. "An in-depth analysis of the Entertainment Preferences before and after Covid-19 among Engineering Students of West Bengal". International Research Journal on Advanced Science Hub, 5, 03, 2023, 91-102. doi: 10.47392/irjash.2023.018
10. Ayush Kumar Bar; Avijit Kumar Chaudhuri. "Emotica.AI - A Customer feedback system using AI". International Research Journal on Advanced Science Hub, 5, 03, 2023, 103-110. doi: 10.47392/irjash.2023.019
11. Rajarshi Samaddar; Aikyam Ghosh; Sounak Dey Sarkar; Mainak Das; Avijit Chakrabarty. "IoT & Cloud-based Smart Attendance Management System using RFID". International Research Journal on Advanced Science Hub, 5, 03, 2023, 111-118. doi: 10.47392/irjash.2023.020
12. Suresh P; Justin Jayaraj K; Aravintha Prasad VC; Abishek Velavan; Mr Gokulnath. "Deep Learning for Covid-19 Identification: A Comparative Analysis". International Research Journal on Advanced Science Hub, 4, 11, 2022, 272-280. doi: 10.47392/irjash.2022.068
13. Chirag H B; Darshan M; Rakesh M D; Priyanka D S; Manjunath Aradya. "Prediction of Concrete Compressive Strength Using Artificial Neural Network". International Research Journal on Advanced Science Hub, 4, 11, 2022, 281-287. doi: 10.47392/irjash.2022.069
14. Vishnupriya S; Nirsandh Ganesan; Ms. Piriyanga; Kiruthiga Devi. "Introducing Fuzzy Logic for Software Reliability Admeasurement". International Research Journal on Advanced Science Hub, 4, 09, 2022, 222-226. doi: 10.47392/irjash.2022.056
15. GANESAN M; Mahesh G; Baskar N. "An user friendly Scheme of Numerical Representation for Music Chords". International Research Journal on Advanced Science Hub, 4, 09, 2022, 227-236. doi: 10.47392/irjash.2022.057
16. T. Pravin, C. Somu, R. Rajavel, M. Subramanian, P. Prince Reynold, Integrated Taguchi cum grey relational experimental analysis technique (GREAT) for optimization and material characterization of FSP surface composites on AA6061 aluminium alloys, Materials Today: Proceedings, Volume 33, Part 8, 2020, Pages 5156-5161, ISSN 2214-7853, https://doi.org/10.1016/j.matpr.2020.02.863.
17. Pravin T, M. Subramanian, R. Ranjith,Clarifying the phenomenon of Ultrasonic Assisted Electric discharge machining, “Journal of the Indian Chemical Society”, Volume 99, Issue 10, 2022, 100705, ISSN 0019-4522, Doi: 10.1016/j.jics.2022.100705
18. M. S. N. K. Nijamudeen, G. Muthuarasu, G. Gokulkumar, A. Nagarjunan, and T. Pravin, “Investigation on mechanical properties of aluminium with copper and silicon carbide using powder metallurgy technique,” Advances in Natural and Applied Sciences, vol. 11, no. 4, pp. 277–280, 2017.
19. T. Pravin, M. Sadhasivam, and S. Raghuraman, “Optimization of process parameters of Al10% Cu compacts through powder metallurgy,” Applied Mechanics and Materials, vol. 813-814, pp. 603–607, 2010.
20. Rajashekhar, V., Pravin, T., Thiruppathi, K.: A review on droplet deposition manufacturing a rapid prototyping technique. Int. J. Manuf. Technol. Manage. 33(5), 362–383 (2019) https://doi.org/10.1504/IJMTM.2019.103277

DOI:10.46647/ijetms.2023.v07i03.011 ISSN: 2581-4621

21. Rajashekhar V S, Pravin T, Thirupathi K, Raghuraman S.Modeling and Simulation of Gravity based Zig-zag Material Handling System for Transferring Materials in Multi Floor Industries. Indian Journal of Science and Technology.2015 Sep, 8(22), pp.1-6.

22. J. H. Hubbell, S.M. Seltzer tables of X-ray mass attenuation coefficient and mass energy absorption coefficient 1 keV to 20MeV for elements z-1 to 92 and 48 additional substances of dosimetric interest. 1995.

23. Teli M.T. Chaudharian L.M. and Malode S. S. Attenuation coefficient of 123KeV gamma radiation by dilute solution of Sodium Chloride. 45, 987, Appli. Rasiat Isot. 1994.

24. Teli M.T. Chaudharian L.M. and Malode S. S. Study of absorption of 123KeV gamma radiation by dilute solution of Zinc Sulfate. 32, 410, Ind. J. of Pure and Appli. Phys.1994

25. J. H. Hubbell, Photon mass and energy attenuation coefficient 1 keV to 33, 1269. Int. J. Appli. Radiat. Isot.1982.

26. S. R. Mitkar and S.M. Dongarge-Measurement of linear and mass attenuation coefficient of alcohol soluble compound for gamma rays energy 0.511MeV. Archives of Applied Science Research, 4, (4):1748-1752. 2012.

27. L.Chaudhari and M. Teli, "Linear attenuation coefficient of gamma radiation for dilute solutions of Potassium chloride", Applied Radiation and Isotopes, vol. 47 no. 3, pp. 365-367. 1996.

28. N. Cutshall, I. Larsen and C. Olsen, "Direct analysis of Pb-210 on sediment samples: a self-absorption corrections," no. 309-312. Nuclear Instruments and methods in Physics Research, vol. 206, 1983.

29. S. Dongarge, P. Wadkar and M. Teli, "Measurement of Linear attenuation coefficients of gamma rays for ammonium sulfate salts by aqueous solution method", , vol.2, pp. 1-8. International Journal of Physics and Applications **2010.**

30. J. H. Hubbell, S.M. Seltzer tables of X-ray mass attenuation coefficient and mass energy absorption coefficients, National Institute of Standareds and Technology, Gaithersburg, Md., USA, **2004.**

31. I. Akkurt, S. Kilincarslan, C. Basyigit Annals of Nuclear Energy 13, 577, **2004.**