Aryabhatta Knowledge University, Patna
Collaborative Research Proposal Form

Submitted by

Dr. Rakesh kumar Singh, Head

Center for Nanoscience and Nanotechnology, Aryyabhatta Knowledge University, Patna

and

Prof. Dinesh Rngappa, Head

Nanotechnology Center, VTU, Bangalore

Project title-Preparation, Structural, Magnetic and Optical Properties of non Stoichiometric K^{1+} /Li^{1+} substituted Magnesium Ferrite Magnetic Nano materials as Functional Materials.

Title of the project	reparation, Structural, Magnetic and Optical Properties of non Stoichiometric K^{1+} /Li^{1+} stituted Magnesium Ferrite Magnetic Nano M materials as Functional Materials.
Designation	Asst. Prof. Cum Academic(I/C)
Department	Center for Nanoscience and Nanotechnology
College name	Aryabhatta Knowledge University, Patna
Email ID	rakeshsinghpu@gmail.com
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Research Credential of PI(no. of papers published in Scopis/SCI indexed journals or UGC listed Journals,patents, Books, Book Chapter	Attached in Annexure-A of page no. 7-13 Total no. of papers published/ Accepted is about 75 in the area of Magnetic nanomaterials(Engineering materials), Nanotechnology in Food, Agriculture and Ayurvedic Science and innovative method of teaching-Learning Science through experiment.

A. Details of Co-PI(Max.4)

Co-PI Details	**1**	**2**	**3**	**4**
a) Name of Co-PI	Prof. Dinesh Rangappa			
b) Designation	Professor and Head			
C) Department	Nanotechnology			
d) Address	Center for Post-graduate studies, Muddenahalli, Karnataka-562101			
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h)Research Credential of PI(no. of papers published in Scopis/SCI indexed journals or UGC listed Journals,patents, Books, Book Chapter	Attached in Annexure-B of page no. 14-20			

Note- Present research project is being submitted in collaboration between nanoscience center of AKU and VTU. Other than, this project may be useful for M.Tech or Ph.D. degree research project of Nanoscience center of AKU.

B. JUSTIFICATION OF THE PROJECT

a) Objective and Relevance of the project(Not more than 200 words)

The aim of the proposed research work is preparation and characterization of nanometric size monovalent non-stoichiometric Li/K substituted ferrite particles so as to obtain better understanding of nanometric phase behaviour for hydroelectric cell as energy geneneration and for other purposes in the area of science and Technology. Non-stoichiometry causes the crystalline size, pore size to be non-uniform. Such non-uniformity alters the tetrahedral-octahedral interaction forces, magnetic properties, Curie temperature and optical behaviour. Such properties may have possible applications in memory component, Circulator, isolator, microwave devices, Hydroelectric cell etc. The properties of such engineering materials depends on method of synthesis, annealing temperature and substituted metals. We proposed to prepare this materials using low cost chemical based citrate precursor technique. The prepared materials will be characterized using modern scientific tools, such as-X-ray difractometer, Vibrating sample magnetometer, Scanning or Transmission electron microscope. The details are discussed in methodology section. On the basis of the obtained results, we will try to publish the research finding or in other possible applications.

b) Need of the present research (Not more than 200 words)

Due to interesting structural, magnetic, and optical properties nanocrystalline ferrite materials are gaining a lot of attention because of decrement in their size from bulk to nanorange. Having said that one such material is ferrite-an engineering Material, which is iron based metal oxides with ferrimagnetic behaviour. Among them the lithium/Potasium ferrites found an intense class of materials having spinal structure with profound applications .This leads shift the scientists to move in the direction of alkali metal (like lithium, potassium etc) substituted ferrite nanomaterial have found large applications in microwave devices , digital recorder , sensor, transformer core , optoelectronics devices, Hydroelectric cell etc . They are also a promising replacement of garnets materials as of low-cost . The spinal ferrites have low Curie temperature but it has been reported that lithium or its substituted ferrites have high curie temperature which has also increases its applications in several areas of Science and Technology. Thus in the present study an effort will be carried out to study the effect of not only substitution of lithium but also its non-stoichiometric substitution on structural, optical and magnetic properties of ferrite nanomaterials.

Hence different substituation and annealing temperature may alters properties of materials at nanoscale. Title of the research is well connected to proposed finding.

c) **Social relevance of the project(** Not more than 200 words**)**

Ferrites are important in engineering materials because they possess spontaneous magnetic moment below the Curie temperature and high resistivity. It has a wide selection of applications supported by their magnetic, electrical properties. In recent years materials become the important application in microwave devices, filters, high sensors, water purification, hydroelectric cell, high frequency appliocations etc. With the increasing market trend, the need of ferrites needs to amendment additionally. Another application of the ferrites lies within the automotive business and last in hybrid cars also. Hexa ferrite is a highly magnetic material which has high packing density. Studies of this Material has found applications in magnetic cards, strips, speakers, and magnetic tapes. It is a metal oxide, One area in particular it has found success in his long term Data Storage. So, such materials may be potential candidate for Electronics industries, Environmental science, purification of water and some others.

d) **Research methodology (** Not more than 500 words**)**

The work can be divided into three parts. The first part is sample preparation, the second part is characterization of samples and the third part is interpretation of the data so as to get better overall understanding at nano scale.

Sample Preparation:

The first part of the proposed work involves preparation of ferrite samples. Out of the several methods that have been used for preparing nanocrystalline samples. We have chosen a citrate precursor method. This is because this method can yield very small particles having size down to 5nm and secondly, this method is relatively unsophisticated, so that sample preparation using this method is manageable within our own chemistry laboratory. A Ferrite has the general formula $XO.Fe_2O_3$ where X stands for a divalent metal atom. The procedure for preparing the ferrite sample involves the following steps:

1. A monovalent, divalent metal nitrate is chosen as starting material for preparation of the ferrite sample. This is because nitrate of most of the metals is highly soluble in water. We also take Ferric Nitrate.
2. These two are taken in stoichiometric proportion and warmed in an aqueous solution of citric acid. The slurry resulting from this process is dried in an oven at about 70 C. This gives us the citrate precursor for the nanocrystalline ferrite sample.

3. The precursor is annealed at different fixed temperatures in a temperature-controlled furnace to give nanocrystalline ferrite particles of different sizes.

Characterization: In order to study the properties, we plan to use several characterization tools. X-Ray powder diffraction will be used to study the crystalline size as well as phase of the compound prepared. We also plan to use transmission electron microscope to obtain the particle shape and size distribution within the sample. To study magnetic behavior of the nanometer size samples, we propose to employ vibrating sample magnetometer. We also plan to supplement this study with FTIR, PL and UV-Visible-NIR spectrometer for optical measurement.

Interpretation: Once sufficient data has been obtained, we will try to interpret them so as to draw conclusion regarding the behavior of these nanoparticles. Finally we will try to use these materials for energy generation in Hydroelectric cell or publish research finding for other scientific areas.

e) **Action plan for 1 year**

During the first year we plan to do sample preparation in 4 month and characterization work completion in next 4 month. The main work is interpretation of data obtained and comparison with other similar work – all these will be possible before completion of 1 year.

f) After completion of project report in a year, Publications/ product etc. as a outcome of this project process will be initiated. Results and interpretation of observed data will be linked for possible applications in science and technology as mentioned in objective section.

g) **Technical Novelty and Utility(** Not more than 200 words**)**

Ferrites and ferrite based composite materials have wide applicability in the fields of integrated electronics, Hydroelctric cell, microwave devices, sensors and transducers, magnetic cores, electromagnets, as well as biological and biomedical applications including cancer therapy. Nanocrystalline Ferrites in particular are of recent interest because of their applicability in fields such as magnetic storage devices where the particle size determines the density of storage of information. At present, a lot of attention is being paid on preparation and characterization of nanocrystalline phase ferrites with specific value of magnetization, porous structure, Curie temperature and crystalline size. It has been found that Non-Stoichiometric ferrite Magnetic nanoparticles have been synthesized. The increase of the Curie temperature with increasing potassium Li^{1+}Content (non magnetic ion) is very useful for the different applications specially memory component, the microwave devices, isolators and circulators and the very materials can be used in other industries due to its Magneto –

Opto- electronic properties. Non- stoichiometric compositions provide an opportunity to incorporate more Mg/Li in the material which increases the oxygen deficiency which modifies the exchange interaction hence, enhancing the Curie temperature, useful for Hydroelectric cell and other area of science and Technology.

h) **Available and Complementary experimental infrastructure in the institutes for this project**

Instrumentation facilities at Aryabhatta Centre for Nanoscience & Nanotechnology, Aryabhatta Knowledge University (AKU), Patna, Bihar

Sl. No.	Instrument	Model	Make
1	X-Ray Diffractometer with temperature variation facility	D8 Advance	Bruker, Germany
2	Scanning Electron Microscopy	EVO 18 Research	Carl Zeiss Microscopy Ltd., UK
3	Impedance Analyser (20Hz-120MHz))	E-4490A	Keysight Technologies, USA
4	Nanoparticle Tracking Analysis system	NS-300	Malvern Instruments UK
5	Automatic pH and Conductivity meter	SevenExcellence	Mettler Toledo AG, Switzerland
6	Measuring Balance	New Classic MS	Mettler Toledo AG, Switzerland
7	Dynamic Light Scattering Particle Size	NanoPlus	Micrometrics Instruments Corp.,USA
8	Microwave Assisted Hydrothermal Technique	RotoSYNTH	Milestone, Italy
9	Atomic Force Microscope cum Scanning Tunnelling Microscope,	NT-MDT	Ntegra,Ireland
10	FTIR spectrophotometer	Frontier	PerkinElmer, UK
11	UV/VIS/NIR spectrophotometer with temperature variation facility	Lambda 950	PerkinElmer, UK
12	Ball Milling Machine	Emax	Retsch, Germany

Some others facilities available at Nanotechnology center, VTU. TEM and elemental composition facilities may be possible at NPL, IISc on chargeable basis.

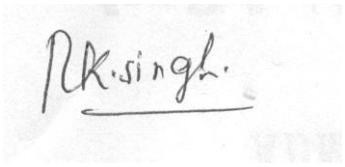
C. Recurring Budget

Sr. No	Components	Ceiling amount	Amount required	Sanctioned (INR)
1	Consumables relevant to proposed research proposal	1,05000.00		
2	Travel for research activities only	60, 000.00		
3	Patenting/Registration fee for Conferences/Seminars/workshops/Training programme	50,000.00		
4	Outsourcing related to research work(i.e. Prototyping/Fabrication/testing/Characterization/ calibration etc.) and Software	1,00,000.00		
5	Project Contingencies	15,000.00		

Total CRS Budget Estimate by PI	
Total CRS grant sanctioned by AKU	

D. Account details of PI

Name	Dr. Rakesh Kumar Singh
Account No.	33332598429
Bank	SBI, CNLU, Patna
Branch	CNLU Patna
IFSC code	SBIN0015996



15th Sep 2019

Dr. Rakesh Kumar Singh(P.I)
Academic(I/C), Nanoscience and Technology Center
AKU, Patna
Signature of PI

Signature of Principal

Annexure-A

Research Publications (Last 5 years in peer reviewed Journal)

1. Study on Physical properties of Ayurvedic TamraBhasma as nanomedicine. J. of Ayurveda and Alternative medicine. Elsevier. DOI.10.1016/j.jaim/2017.03.001(2019).
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13. Competition between strain and super exchange mediated Magnetism in modified Cobalt ferrite nanoparticles, Manuscript ID-K-146, American Institute of Physics (**AIP)**

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16. Structural, Magnetic & Dielectric behavior of $Ni_{0.5}Zn_{0.5}Fe_{1.99}R_{0.01}O_4$**Nanoparticles**; R= Pr, Sm and Gd, synthesized using Citrate Precursor method, annealed at low temperature450^{0}C, Int. J. of Engineering & technical research, 2(2014)125-130.

17. Synthesis of $NiFe_2O_4$ and $MgFe_2O_4$**nanoparticles** through citrate precursor method, annealed at 650C and study their structural & Magnetic properties, proceeding of National conference, VVIT, **ISBN**-978-81-925776-9-2, (2014) p.72-74.

18. Magnetic interaction between ferromagnetic $CoFe_2O_4$ and antiferromagnetic NiO, Physica B-Physics of condensed Matter.530 (2018)114-120.

19. Surface anisotropy induced magnetism BTO-CFO Nano-composite, J.Magn.Mag. Mater.465 (2018)93-99.

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21. Evidence of exchange coupled behaviour in Cobalt-chromium Ferrite Nanoparticles.J.Magn.Mag. Mater.456 (2018)118-123.

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26. Some College and University level experiments that foster research driven learning, proceeding, Int. J. Advance Research in science and Engineering. 6(2017).

Books Published

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28. Statistical Physics, 2017, M.Sc, paper IV of Nalanda Open University, p.05-120.

Research Publications (Before last 5 year)

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7. Nanophosphour : A Luminiscent Materials , A.C. Pandey, **Rakesh Kumar Singh** , proceeding, Nanoscience & Nanotechnology, Patna Women's College.(2008)p.5-11

8. **Rakesh Kumar Singh**, A.Yadav, A.Narayan, M.Chandra and **R.K.Verma**, Thermal, XRD and magnetization studies on $ZnAl_2O_4$ and $NiAl_2O_4$ spinels, synthesized by citrate precursor method and annealed at temperature 450^{o}C and 650^{o}C, J. Thermal, Analysis& Calorimetry-**Springe**r, DOI 10.1007/s10973-011-1860-7 (2011).

9. **Rakesh Kumar Singh,** A. Yadav, A. Narayan, Samar Lyeak, **H. C. Verma,** Structural, Magnetic and Mossbauer studies of Nanocrystalline Ni-Zn Ferrite, Synthesized using Citrate precursor method, Manthan, Int. J, Vol.12(2011)9-11

10. **Rakesh Kumar Singh**, A.Yadav, A.Narayan, Amar endra Kr Singh, L.Verma and **R.K.Verma**, Thermal, structural and magnetic studies on Chromite spinel , synthesized by citrate precursor method and annealed at temperature 450^{o}C and 650^{o}C, J.Therm Anal Calorim- **Springer**, DOI 10.1007/s10973-011-1869-y (2011)

11. **Rakesh Kumar Singh**, A. Narayan, S.B.Ansari, Hg Fe_2O_4 and Cd Fe_2O_4 Ferrite Nanoparticles synthesized by annealing temperature at 450^oC : Structural, Magnetic and Photoluminiscent properties, **Millenium series**, Mendel, Int. J. vol.27(3-4), 89-92(2010).

12. **Rakesh Kumar Singh, A**. Narayan, R.N.Roy and. **Avinash C. Pandey**, Preparation of mixed phase Strontium Ferrite and effect on Magnetic properties, Manthan, Int. J. Vol.13 (2012) p.26-29.

13. **Rakesh Kr Singh**, C. Upaadhyay, Samar Lyeak, A. Yadav, Cations distributions in $Ni_{0.5}Zn_{0.5}Fe_2O_4$ Nanomaterials**,** Int. J. Sci. Eng. and Tech. **(I-JEST)**, Special **issue Nano iron oxides and composites – recent avances in Scientific and technological aspects**, Vol.2, No.8. (2010), p. 104-109.

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19. **Rakesh Kumar Singh** and Amarendra Narayan, Nickel-Zinc ferrite Nanoparticles: Synthesis and Characterization, Proceeding of National Conference on nanomaterials and Nanotechnology, Dept. of Physics, University of Lucknow, (2007), p.118-121.

20. **Rakesh Kumar Singh**, A.Yadav, A. Narayan, Girija Gupta, Amitabh Ghosh, Structural, Magnetic and Photoluminiscent behaviour of Cobalt Ferrite Nanoparticles prepared using chemical method, Proceeding of National Seminar on Applications of Nanoscience and Nanotechnology, Patna Women's College(2008)p. 22-26.

21. **Rakesh Kumar Singh**, Madhu Rani Sinha and R.N.Tagore, "Magnetic Nanoparticles in Biological Sciences: a review," Accepted for publication in proceeding of international conference on recent trends in life sciences researchers VIS-A-VIS, natural resources management, sustainable Development and Human welfare- 27 June 2009, Vinoba Bhabe University, Hazaribagh,

22. **Rakesh Kumar Singh**, A.Yadav, A.Narayan, Structural and Magnetic studies of Zn substituted Cobalt ferrite nanoparticles annealed at 450^oC, Manthan, Int. Jour. Vol.11, (2010), p.31-35.

23. **Rakesh Kumar Singh**, Nishit Pandey, Amarendra Narayan. Mossbauer studies of Barium Hexa-ferrite Nanoparticles annealed at 600^{o}C, synthesized using Citrate precursor Method, **MSI bulletein**, (2010), p.39-41.

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Research Papers in **Explore- Journal of Research for Undergraduate and Postgraduate students**

Under the College with Potential for Excellence (CPE) status scheme by UGC, Govt. of India, Scheme, **embodies the research work of my students as a co-authors.**

Detail-

Detail- Patna women's College, Patna University is **'A' Grade institution with a cumulative Grade point average (CGPA) of 3.58 out of 4 and also College with potential for excellence status (**CPE**) status accorded by UGC**. Under these status UGC has given special grant for inculcate scientific research temper among Science graduate students. Under **Basic Scientific Research (BSR)** and **College with potential for excellence status (**CPE) status scheme group of students (2 to 3 in a group) undertake **research project** in a specific area or topic under the supervision of a teacher in the department. The students collects data/materials, organize these and after analysis and inference, present their finding in the form of a written report under the supervision of teacher in the Dept. Subsequently they modify the content of their research and finding in the form of a research paper and a PPT presentation. A panel of judges evaluate the quality of research and the best presentations will be review by advisory committee and finally recommended their article for publishing in this scheme I have supervised 9 project under CPE scheme and 7 project under BSR scheme during the period from August 2004- 2013(worked as Asst. Professor). The published work are following-

ISSN 2278-0297(Print), ISSN 2278-6414(online), http:patnawomenscollege.in/journal

26. **Rakesh Kumar Singh**, Rakshan Noor, Vijeta Mishra, Priya Tiwari · Synthesis, Structural and Magnetic properties of $Ni_{0.8}M_{0.2}Fe_2O_4$ (M=Co,Cu) nanoparticles synthesized by Citrate Precursor Method, Explore, J. of Research for UG & PG students, Vol. IV, (2013) – In press.

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33. Nisha Kumari, Sushmita Prakash, **Rakesh Kumar Singh**, Synthesis, Structural and Magnetic Studies of Nickel Substituted Cobalt Ferrite Nanomaterials ($Ni_{0.07}Co_{0.93}Fe_2O_4$) via Citrate Precursor Method, Explore, Vol. II, (2010).1-5

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35. Sonam Parween, Neha Kumari, Puja Padey, **Rakesh Kumar Singh**, Zinc and Nickel substituted Cobalt Ferrite Nanoparticles synthesized using Citrate precursor method, annealed at 450°C, Explore, Vol. II, (2010), p. 1-3

36. Anjali Kumari, Nancy Goenka, **Rakesh Kumar Singh**, Growth, Structural and Magnetic studies of Rare earth element Ce substituted Zn Ferrite Nanoparticles via Citrate precursor method, Explore, Vol. II, (2010) p.19-22.

Research Papers in IRIS — Journal for Young Scientists.

Under the Basic Scientific Scheme (BSR) special Scheme of UGC, Govt. of India, **embodies the research work of my students as a co-authors.**

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Total research publication is about 81 (53+28= 81) in last 15 year

Details of Some more Research Articles communicated/Under review

5 papers have already reported for publications in following journals and are under review. Material Science & Engineering-B, Journal of luminescence, J. of Magnetic Materials & Magnetism, Journal of Alloys and Compound as author/co-author

Annexure-B

Research publications of Co-PI

Dr. Dinesh Rangappa

Prof. and Head, Nanotechnology Center, VTU

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1. Aparna Nadumane, Krushitha Shetty, KS Anantharaju, HP Nagaswarupa, **Dinesh Rangappa**, YS Vidya, H Nagabhushana, SC Prashantha "Sunlight photocatalytic performance of Mg-doped nickel ferrite synthesized by a green sol-gel route" Journal of Science: Advanced Materials and Devices, 4, 89-100, 2019.
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