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# MAGNETISM AND MAGNETIC MATERIALS

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# ACCEPTED ABSTRACTS

Mater Sci Nanotechnol 2018, Volume 2

# EVALUATION OF AGING AND HYDRATION IN NATURAL VOLCANIC GLASS: MAGNETIC PROPERTY VARIATIONS DURING ARTIFICIAL AGING AND HYDRATION EXPERIMENTS

**Fatimah Abdulghafur**
University of Wisconsin-Milwaukee, USA

The recorded geomagnetic field intensity is a function of magnetic mineralogy, grain size, and mineral concentration as well as material stability in nature and during laboratory experiments. Fresh, unhydrated, volcanic glasses are recognized as a nearly ideal natural material for use in paleo intensity experiments because they contain the requisite SD to PSD magnetic particles. It is unclear how mineralogy and hence magnetization might change with age as the metastable glass structure relaxes and/or the glass becomes hydrated. Bulk magnetic properties as a function of age show no clear trend, even over hundreds of millions of years. This may be since even in fresh glass, there are small-scale differences in magnetic properties due to variation cooling rate or composition variations. Therefore, to better understand how magnetic mineralogy evolves with time and hydration, we conducted artificial aging and hydration experiments on fresh, unhydrated rhyolitic and basaltic glasses. Here, we present the results of these experiments. Aged samples are dry- annealed at 200°C, 300°C and 400°C for up to 240 days. A second set of samples are hydrated under pressure at 300°C and 450°C. In all cases IRM acquisition is monitored to assess changes in the coercivity spectrum and sIRM. Preliminary aging results show that in basaltic and rhyolitic glass there is one main peak coercivity at ~ 150 mT and ~ 35 mT, respectively. An increasing sIRM and decreasing peak coercivity trend is observed in basaltic glasses whereas no trend is shown in the rhyolitic glass in both parameters after 240 days for all temperatures in aging experiment. This could be caused by the coarsening of the existing magnetic grains as the glass structure relaxes during to aging. We tentatively conclude that one should be cautious with using older glassy samples in absolute paleointensity experiments.

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# LABEL-FREE RAPID SILICON NANOTECHNOLOGY STRATEGY FOR SERS DETECTION OF GLYCANS ON LIVE CELLS

**Aisha Bibi**[1,2] and **Yao He**[1,2]
[1]Institute of Functional Nano and Soft Materials, China
[2]Collaborative Innovation Center of Suzhou Nano Science and Technology, China

Basically, glycan beautifies all mammalian cell surfaces through glycosylation. Glycan is one of the most important post-modifications of proteins. Glycans on cell surfaces facilitate a wide variety of biological processes, including cell growth and differentiation, cell-cell communication, immune response, intracellular signaling events and host-pathogen interactions. High-performance optical sensors are very important for rapid, sensitive and precise detection of chemical and biological species for various fields, including biomedical diagnosis, drug screening, food safety, environmental protection etc. To explore the novel kinds of sensors with low cost, portability, enough sensitivity, high specificity, excellent reproducibility, and multiplexing detection capability remain in high demand. Therefore, a significant advancement of silicon nanotechnology, functional silicon nanomaterials/nanohybrids (e.g., fluorescent silicon nanoparticles, gold/silver nanoparticles-decorated silicon nanowires or silicon wafer, etc) featuring unique optical properties have been intensively employed for the design of high-quality fluorescent and surface-enhanced Raman scattering (SERS) biosensors. Therefore, currently exists increasing concerns on the development of a kind of high-performance SERS platform, which is suitable for glycan expression of different cell lines and as well as used for the sensitive detection of glycans on live cells. Herein, we introduce the possibility of silicon-based probe for biomolecules of interest near cells using SERS.

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# THERMODYNAMICS OF METAMAGNETOELECTRIC EFFECT IN MULTIFERROICS

**F Kuate Fodouop[1], G C Fouokeng[1,2], M Tchoffo[1] and L C Fai[1]**
[1]University of Dschang, Cameroon
[2]Institut Universitaire de la Côte, Cameroon

Magnetoelectric coupling factor in multiferroics give rise to various properties such as metamagnetoelectric effect since an external field act. In this study, a general thermodynamic framework is developed to investigate metamagnetoelectric effects in multiferroic materials. The model used is a quasi-two-dimensional frustrated spin chain controlled by a static electric field in y direction and magnetic field in z-direction. The effects of metamagnetoelectric transitions on entropy, specific heat and on the linear magnetoelectric coupling factor are assessed using Fermi Dirac statistics of quantum gases and the Landau theory. The entropy behavior is shown like that of the magnetic susceptibility. In fact, while the magnetic susceptibility characterizes the variations of magnetization and accordingly emphasizes the ferroic transition points of this order, the intrinsic physics of these transition points highlights a muddle occurring due to a rearrangement of magnetic moments in the system, and this is accurately described in terms of entropy. The transition effects due to this rearrangement described in terms of entropy at the corresponding critical points show different loop to that of the specific heat. The opposite loop showed by the specific heat compared to the entropy is its weakening at the exact transition point despite its strengthening during the transition process. The temperature dependence of the magnetoelectric coupling highlights how it is continuously weakened beyond the transition point. This shows for any point defined by a pair of values of electric and magnetic fields, the range of temperature which allows metamagnetoelectric effect and how it vanishes continuously when the temperature increases.

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# CALCULATION OF ANISOTROPIC EXCHANGE COUPLING CONSTANTS IN IRIDATES

**Alexander Yaresko**
Max Planck Institute for Solid State Research, Germany

Because of strong spin-orbit coupling within the Iridium 5d shell magnetic interaction in $Ir4^{+}$ oxides cannot be described by an isotropic Heisenberg-like model and anisotropic exchange interactions become important. In α-$Na_2IrO_3$ and α-$Li_2IrO_3$, in which edge sharing IrO octahedra form a honeycomb lattice, magnetic interaction was suggested to be bond-dependent and to be described by the Kitaev model. Recently, another complex Ir oxide β-$Li_2IrO_3$ has been synthesized which is expected to be close to forming a Kitaev spin liquid. Ir ions in this compound form a "hyper-honeycomb" lattice, a three-dimensional analogue of the honeycomb lattice of α-$Na_2IrO_3$. In $Sr_2IrO_4$, $Sr_3Ir_2O_7$ and in $R_2Ir_2O_7$ compounds, where *R* is a rare-earth ion, with the pyrochlore structure, on the other hand, the dominant anisotropic exchange is the anti-symmetric Dzyaloshinskii–Moriya interaction. We present results of LSDA+U band structure calculations for $Na_2IrO_3$, $Sr_2IrO_4$, and some $R_2Ir_2O_7$ iridates. The strength of the Coulomb repulsion U is adjusted by comparing the calculated optical conductivity to experimental optical spectra. Then, magnetic interactions in these compounds are estimated by mapping the total energy calculated for various non-collinear magnetic configurations constrained by magnetic symmetry onto an effective model which includes isotropic Heisenberg-like as well as bond-dependent anisotropic magnetic interactions. It is shown that the variation of the total energy cannot be described by the isotropic Heisenberg-like model and anisotropic terms may be as strong as the isotropic ones.

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# CORRELATION BETWEEN THE ELECTRONIC STRUCTURES AND MAGNETIC PROPERTIES OF XE AND AR IONS IMPLANTED ZNO

**Barun Ghosh**
University of Nottingham, United Kingdom

A strong correlation between the electronic structures and magnetic properties of unimplanted ZnO single crystal (ZnO-SC) and xenon ($Xe_{3+}$)/argon ($Ar^+$) ions implanted ZnO SCs has been investigated using x-ray absorption near edge structure (XANES) spectroscopy, valence band photoemission spectroscopy (VB-PES), x-ray photoelectron spectroscopy, ultraviolet photoelectron spectroscopy, and a superconducting quantum interference device-type magnetometer. The XANES studies reveal the higher number of unoccupied p-states in implanted ZnO SCs than pristine ZnO SCs. The enhancement in the absorption intensity of the XANES spectra of implanted ZnO represents the enhanced local density of states (DOS) that arise from the surface defects or dangling bonds in ZnO. In implanted ZnO SCs, the binding energy of the Zn $2p_{3/2}$ core level peak shifts, which further confirms an increase in the valence band maximum (VBM) position. The VB-PES spectra clearly change upon ions implantation, becoming broader, implying the induced surface defects in ZnO-SC. VB-PES study also reveals that the number of electrons in the valence band of the O 2p–Zn 4sp hybridized states of the implanted ZnO is higher than in the pristine ZnO. The magnetic M–H loops demonstrate an enhanced room temperature ferromagnetism (RT-FM) in Xe/Ar ions implanted ZnO SCs, which is attributed to the increasing number of surface defects and/or native defect sites such as oxygen vacancies and zinc interstitials. This increased RT-FM is strongly related to the enhancement of VB-DOS of O 2p states close to Ef, because the population of defects and/or vacancies at the O sites in irradiated ZnO is higher than pristine ZnO, which is confirmed from VB-PES as well as UPS studies. This study confirms an enhanced room temperature ferromagnetism in Xe/Ar ions irradiated ZnO-SC without ant transition metal doping which could be used in different electromagnetic applications.

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# PROBING TRIPLET SUPERCONDUCTIVITY BY THE ANDREEV-EDELSTEIN EFFECT

**Grigory Tkachov**
Wuerzburg University, Germany

An unambiguous identification of spin-triplet superconductivity is one of the outstanding problems in condensed matter physics. The author will present a new approach to this problem based on using Andreev reflection in combination with the Edelstein effect. The latter refers to the spin magnetization produced by an electric supercurrent in a noncentrosymmetric superconductor. The author will discuss the combined Andreev-Edelstein effect which consists in the generation of equal-spin triplet Andreev reflection by a supercurrent. This effect is a smoking gun for the nonunitary triplet pairing which is characterized by cooper-pair spin magnetism. Both intrinsic and proximity-induced on centrosymmetric superconductors will be addressed. In the latter case, we will focus on the topological insulator surface states which, in general, offer an excellent playground for studying the Edelstein and related magnetoelectric effects.

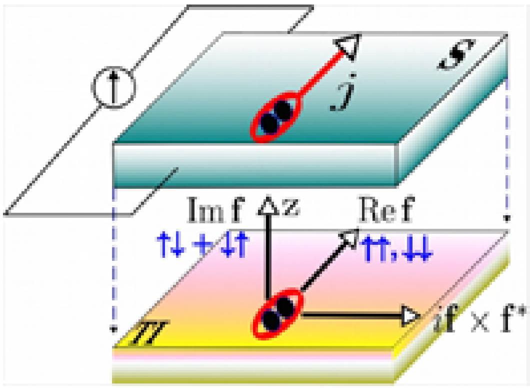


**Fig. 1.** Schematic of a topological insulator (TI) proximitized by a current-biased superconductor (S); j is the supercurrent density. The supercurrent generates nonunitary triplet pairing described by a complex pair amplitude f with orthogonal real and imaginary parts. The axial vector if × f* characterizes the spin magnetization of the nonunitary triplet condensate

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# BEHAVIOR OF NANO SIZE DEFECTS IN THE MAGNETIC PROPERTIES OF RPV STEEL STUDIED BY SMALL ANGLE NEUTRON SCATTERING MAGNETIC METHODS

**Duk Gun Park, KH Kim** and **KM Kim**
Korea Atomic Energy Research Institute, South Korea

Fe-Cu alloys are commonly used for a simulation of radiation damage of RPV steel because a neutron irradiation enhances the copper precipitates which is known as the primary reason of a RPV embrittlement. An investigation of thermal aged Fe-Cu model alloy has been a common and adequate alloy for a study of this purpose. For this purpose the selected annealing temperature is sufficiently low (753K) compare with the solubility limit (e.g. 1023K for Fe-1wt%Cu). The behavior of copper precipitations in the Fe-Cu alloy which is used as a simulation of radiation damage was investigated using a small angle neutron scattering (SANS). The alloy was made through a melting with pure Fe and pure Cu. Initially, the alloy is 10% cold rolled, and isothermally aged at 753 K for 20, 200 and 1800 min. The CRPs sizes, volume fractions and A-ratio of Fe-Cu alloy with aging time are obtained from the SANS data analysis. The sizes of Cu precipitates nearly constant up to aging time of 200 min and fast increased, but the volume fraction of Cu precipitates linearly increased with aging time. The investigation is focused on the behavior of copper precipitates with aging time in the 10% cold rolled Fe-Cu alloy. The objective is to identify the aging time dependence of precipitates evolution such as volume fraction and size distribution.

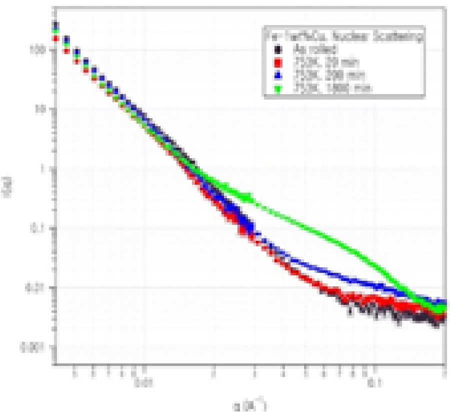

**Fig.1:** Nuclear (left) and magnetic (right) SANS components as a function of wave-vector transfer Q for the Fe-Cu alloy with 10% pre-strained measured at room temperature with different aging time at 753K.

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# FORMATIVE BIO FABRICATION USING MAGNETIC LEVITATION

**Vladimir Mironov**
3D Bioprinting Solution and Sechenov Medical University, Russia

Several research groups in USA, Turkey and Russia recently demonstrated the principal feasibility of magnetic levitational bio assembly of tissue engineered constructs from living tissue spheroids in the presence of paramagnetic medium. However, employed paramagnetic medium containing Gadolinium is relatively toxic at concentration enabling magnetic levitation. Using high magnetic field at The European High Field Magnet Laboratory (HFML) at Nijmegen, The Netherland it was possible first time to perform magnetic levitational assembly of tissue constructs from tissue spheroids bio fabricated from osteosarcoma cells at 100 times lower concentration of Gadolinium. High magnetic field in this situation works as a temporal and removal support or scaffold. The magnetic levitation can serve as an earth-based model of space microgravity. Thus, formative bio fabrication of tissue engineered constructs from tissue spheroids in the high magnetic field is a promising research direction.

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# MAGNETIC MATERIALS FOR WIRELESS ACTUATION IN BIOMEDICINE

**Gioia Lucarini**
The BioRobotics Institute, Scuola Superiore Sant'Anna, Italy

This talk introduces the key aspects of magnetic actuation for medical devices in the miniature scale, based on the research group's experience on robotics for minimally invasive intervention, targeted therapy, personalized medicine or bionic artificial organs. The quest for miniaturization and natural access to the targeted pathologies led to the development of diagnostic and therapeutic tools to be delivered with an endoluminal and transluminal approach and to be controlled and propelled by remote operation schemes from outside. The quest for targeted therapy has recently opened new opportunities for robotic technologies, which are used more and more as controllers for the delivery of drugs embedded in nano biotech vectors and as solutions for making therapy really localized in interest, thus enabling on-demand release kinetics and eliminating (or strongly limiting) side effects. After a description of magnetic solutions developed in the speaker's group for actuating, locomoting and triggering mechanisms to be employed in medical devices, the talk will focus on recent applications of magnetic control of microrobots for personalized therapy and lab-on-chip technologies.

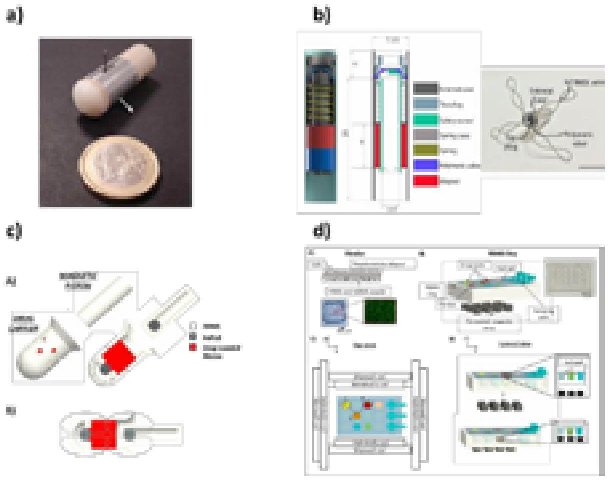

**Figure.1:** Magnetic solutions developed by the speaker. a) magnetic endoscopic capsule, b) magnetic artificial urinary sphincter, c) Untethered magnetic millirobot for targeted drug delivery, d) magnetic films for cell manipulations and lab- on-chip applications.

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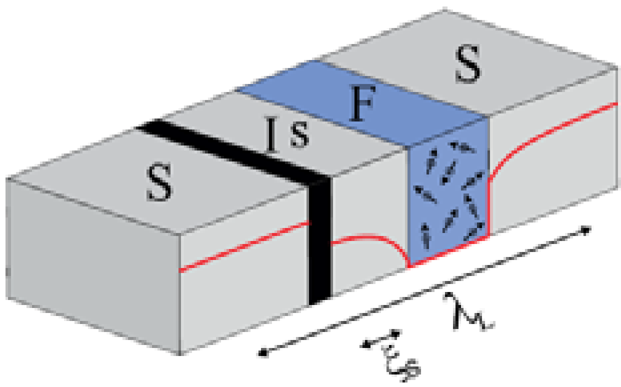
# STATIC AND DYNAMIC PROPERTIES OF JOSEPHSON JUNCTIONS WITH COMPOSITE INSULATOR-SUPERCONDUCTOR-FERROMAGNETIC INTERLAYER

**Sergey Bakurskiy**
Lomonosov Moscow State University, Russia

Nowadays the Josephson junctions with magnetic weak links attract special attention due to their possible applications several future devices, such as superconducting MRAM, logic, quantum bits and neural networks. The interaction between superconducting and ferromagnetic orders in the proximized area of ferromagnetic SFS junctions provides phenomenon of 0- π oscillation of pairing amplitude in the structure. The effect permits to organize superconducting memory devices in new principals. The S-IsF-S junction with composite interlayer consists of tunnel barrier I, thin superconducting film s and ferromagnetic layer F combines high performance of the tunnel SIS junctions and special properties of magnetic SFS devices. We developed a microscopic theory of the electron transport in these devices in the frame of the Usadel equations. We have found that 0- π transition in SisFS junction can be hidden from the direct measurement its current-phase relation (CPR), due to formation of multiple branches in the CPR shape. We demonstrate that the effect is the direct consequence of the significant second harmonic in CPR of the ferromagnetic sFS part of the SisFS device. This fact significantly modifies modes of operation of the structure. Furthermore, we predict the appearance of the superconducting phase domains in the thin superconductive layer s near the domain walls in ferromagnetic material. The properties of the superconducting phase domains have hysteretic nature and depend on the direction of injected current inside the structure.




Schematic design of SIsFS Josephson junction.

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# COMPUTATIONAL SEARCH FOR GIANT MAGNETOCALORIC MATERIALS: APPLICATION TO MNAS

**João S Amaral**
University of Aveiro, Portugal

Current high-performance magnetic refrigerants are the result of years of extensive experimental work, after thousands of samples were prepared and characterized in laboratories around the world. Computational tools to assist the search for new and optimized magnetocaloric materials would be welcome, but the challenges for their development are considerable. The approach must be predictive and not merely descriptive, to be of use. In other words, using experimental results as inputs to a computational approach that is intended to look for new materials somewhat defeats the purpose. While Density Functional Theory (DFT) allows the ab-initio determination of microscopic parameters, these need to be fed to a thermodynamic model to make predictions of performance parameters such as Tc and entropy change. This model must be able to describe first-order phase transitions to allow the search of giant magnetocaloric materials. We here report on the combined use of DFT and Monte Carlo simulations of a compressible Heisenberg-like model, applied to describe the giant magnetocaloric effect of MnAs. Our DFT calculations follow previous reports, estimating the magnetic exchange parameters as a function of structural distortion between the ordered (FM) phase, where the total magnetic and structural energy is minimized, and the disordered (PM) phase, where only the structural energy is minimized. Our estimates of structural and magnetic phase transition temperatures and magnetocaloric effect show good agreement with experimental data, highlighting the entropy change contribution of the structural phase transition. The generalization of this approach to other magnetic systems is discussed.

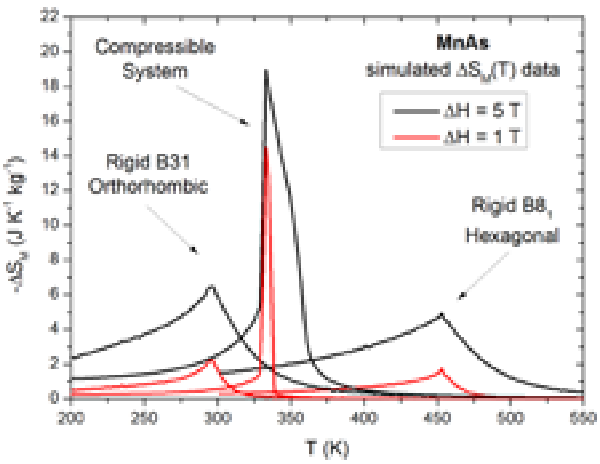


**Figure.1:** Simulated magnetocaloric effect of MnAs, considering rigid hexagonal and orthorhombic lattices, together with the compressible system,which shows a giant magnetocaloric effect.

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# TWO-DIMENSIONAL ANALYTICAL CALCULATION METHOD TO ANALYZE THE MAGNETIC COMPONENTS OF A SUPER ELLIPSOIDAL CAVITY MAGNET FOR A CLAW POLE ROTOR OF AN ALTERNATOR

**Senthil Ram Nagapillai Durairaj, Praveen Chakrapani Rao, Muruganandam Radhakrishnan** and **Thulasirajan Ganesan**
Comstar Automotive Technologies Pvt. Ltd., India

Super ellipsoidal cavity magnet is a novel design, which has a shallow cavity on the surface of the magnet to improve the surface flux density on the magnetic poles and to reduce the leakage flux at the pole interface of the magnet. The super ellipsoidal cavity is created on one surface of the edge chamfered cuboid magnet, which are interposed between the interpole gaps of the claw pole rotor assembly. This paper aims to prove the improved magnetic flux density on the magnetic poles which is analytically analyzed using magnetic vector potential equation and the same has been characterized by comparing it against the simulation of the magnet. The super ellipsoidal cavity magnet is further studied to understand the total magnetic moment change in the volumetric flux, due to the change in volume of the magnet and predicted using the below equation,

$$B_r = \frac{1.027.K_c.\Phi}{V_m}$$

Where Br is the remanence flux density, $K_c$ Helmholtz coil constant,Φ is the volumetric flux and $V_m$ is the volume of the magnet. The total magnetic moment m is the product of coil constant and volumetric flux of the magnet which is denoted by the equation

$$m = K_c.\Phi$$

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# COMBINED EFFECTS OF SQUEEZE AND SLIP FLOW OF AN MHD CASSON FLUID THROUGH A NON-DARCY POROUS MEDIUM

**Akinbowale T Akinshilo**
University of Lagos, Nigeria

This present study considers the effects of squeezing electrically conducting Casson fluid flowing through a non-Darcy porous medium. Since the Casson fluid finds useful applications in flow processes such as jelly processing, tomato sauce production, drilling mud, paint solutions amongst other applications. Nonlinear models developed describing the transport phenomena of the Casson fluid is transformed using similarity variables to ordinary differential equations, which is analyzed adopting the homotopy perturbation method (HPM). Solutions generated from the higher order non-linear equation arising from the mechanics of the fluid utilizing the HPM are used to investigate effects of rheological parameters. Parameters effects such as non-Darcy and slip parameter on fluid flow are examined. Results reveals increasing velocity distribution as slip parameter increases quantitatively when plates are receding and collapsing while for non-Darcy parameter decrease in velocity distribution is observed for quantitative increase in non-Darcy parameter. Comparison of analytical solution obtained against numerical solution proves to be in good agreement. Therefore, present study provides good insights to applications such as hydraulic lifts, electric motors, nasogastric tube and syringe flow amongst other application.

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# STRUCTURAL, MAGNETIC AND DIELECTRIC PROPERTIES OF SOL-GEL AUTO-COMBUSTION SYNTHESIZED MAGNESIUM FERRITE NANOPARTICLES

**Gigel Gicu Nedelcu, Alin Druc, Adriana Popa, Maria Cazacu, Mihai Iacob, Marius Dobromir, Petronel Postolache, Liviu Leontie** and **Felicia Iacomi**
Grigore Ghica Voda Sanitary School Iasi, Romania

In the present work, $MgFe_2O_4$ nanoparticles were prepared by sol-gel auto-combustion method, using glycine as fuel agent. Transmission electron microscopy and scanning electron microscopy (SEM) provided the data on morphological analysis and particle sizes. Structural characterization was performed with x-ray diffraction which has given data about the spinel single-phase formation. Chemical structure has been characterized by Fourier-transform infrared spectroscopy and by x-ray photoelectron spectroscopy which proved the absence of organic phases. The magnetic properties investigated by vibrating sample magnetometry and electron paramagnetic spectroscopy show that the ferrite particles are superparamagnetic behaviour, depending on the chemical composition, shape and size of the particles, the synthesis method, crystallinity, direction of magnetization and cation distribution. Dielectric properties were evaluated by dielectric permittivity and dielectric losses measurements, using an Agilent 4294A Precision Impedance Analyzer, in the range of 40 Hz - 110 MHz.