

Materials, Methods & Technologies 2020

TWENTY-SECOND INTERNATIONAL CONFERENCE

Conference Program

29 AUG - 1 SEP 2020, FLORA EXPO CENTER, BURGAS, BULGARIA

ORGANIZED BY

- Bulgarian Academy of Sciences
- Union of Scientists in Bulgaria
- Science & Education Foundation, Bulgaria
- Al-Farabi Kazakh National University, Kazakhstan
- Institute of Power Engineering, National Academy of Sciences, Belarus
- Institute of Hydrometeorology, Georgian Technical University, Georgia

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REGISTRATION

05:00 – 06:00 PM, 29 August, Flora Expo Center

09:00 – 10:00 AM, 30 August, Flora Expo Center

OPENING

10:00 AM, 30 August, Flora Expo Center

TALK SESSION #1

10:00 – 11:30 AM, 30 August, Flora Expo Center

- 1. DEVELOPMENT OF EXPERIMENTAL MICROFLUIDIC SYSTEM AND METHODOLOGY FOR ASSESSING MICRORHEOLOGICAL PROPERTIES OF BLOOD**
Nadia Antonova
Institute of Mechanics, Bulgarian Academy of Sciences, Bulgaria
- 2. POLYMER MEMBRANES LOADED WITH 8-QUINOLINOL DERIVATIVES WITH ANTIBACTERIAL AND ANTIFUNGAL ACTIVITIES**
Mariya Spasova
Institute of Polymers, Bulgarian Academy of Sciences, Bulgaria
- 3. MATHEMATICAL PROCEDURE FOR ANALYSIS OF DATA OBTAINED BY MEANS OF CIRCULAR DICHROISM TITRATION METHOD**
Krasimira Prodanova
Technical University of Sofia, Bulgaria
- 4. THE INNOVATIONS IN SKIN REPAIR DISORDERS IN THE APPLICATION OF NANOTECHNOLOGICALLY PREPARED HYDROGEL BIOMATERIALS**
Danica Marković
University of Belgrade, Serbia
- 5. TWIN-ROLL CAST Al-Li ALLOYS**
Miroslav Cieslar
Charles University, Faculty of Mathematics and Physics, Czech Republic
- 6. INTERMETALLIC LAYER IN Al-STEEL CLAD STRIP AND INTERDIFFUSION COEFFICIENT**
Barbora Křivská
Charles University, Faculty of Mathematics and Physics, Czech Republic
- 7. STUDY OF AN INNOVATIVE MANUFACTURING PROCESS FOR TITANIUM NITRIDE CERAMIC VIA HYBRID POLYMER COMPOSITES**
Ilie Daniel Timpu
Romanian Academy, Institute of Macromolecular Chemistry "Petru Poni", Romania
- 8. NANO-COMPOSITES WITH TiO₂/SiO₂ AND TiO₂/SiO₂/REDUCED GRAPHENE OXIDE FOR TEXTILE MATERIALS IMPREGNATION**
Ilie Daniel Timpu
Romanian Academy, Institute of Macromolecular Chemistry "Petru Poni", Romania

POSTER SESSION #1

11:30 AM – 12:30 PM, 30 August, Flora Expo Center

9. **THE BRADYRHIZOBIUM JAPONICUM 273 STRAIN'S ABILITY TO DEGRADE PHENOL. PART 1**

Evgenia Vasileva

Institute of Chemical Engineering, Bulgarian Academy of Sciences, Bulgaria

10. **PHENOL BIODEGRADATION OF IMMOBILIZED BRADYRHIZOBIUM JAPONICUM CELLS. PART 2**

Tsvetomila Parvanova-Mancheva

Institute of Chemical Engineering, Bulgarian Academy of Sciences, Bulgaria

11. **ELIMINATION OF IRREGULARITIES AND DEFECTS ON STEEL SURFACES THROUGH ELECTRO SPARK SURFACE MODIFICATION WITH ALUMINUM ALLOYS**

Todor Penyashki

Institute of Soil Science, Agrotechnologies and Plant Protection, Bulgaria

12. **ADDITIONAL METAL PROCESSING TECHNOLOGIES - PROBLEMS AND WAYS OF LEVELING THE SURFACE DEFECTS**

Todor Penyashki

Institute of Soil Science, Agrotechnologies and Plant Protection, Bulgaria

13. **INNOVATIVE PROTECTIVE SYSTEMS AGAINST CORROSION OF GALVANIZED STEEL**

Nikolai Boshkov

Institute of Physical Chemistry, Bulgarian Academy of Sciences, Bulgaria

14. **OPPORTUNITIES FOR DRYING SHRINKAGE MINIMIZING IN FIBER-REINFORCED CONCRETE OVERLAYS FOR REPAIRING OF CORRODED INDUSTRIAL STRUCTURES**

Valeriy Borisov Naidenov

Institute of Mechanics, Bulgarian Academy of Sciences, Bulgaria

15. **INVESTIGATION ON THE EFFICIENCY OF INTERNAL CRYSTALLIZATION CHEMICAL ADMIXTURES FOR CEMENT CONCRETE - MECHANICAL CHARACTERISTICS**

Valeriy Borisov Naidenov

Institute of Mechanics, Bulgarian Academy of Sciences, Bulgaria

16. **INFLUENCE OF THE PHOTOINDUCED CHIRALITY ON THE DIFFRACTION EFFICIENCY OF POLARIZATION GRATINGS INSCRIBED IN AZOPOLYMERS WITH BEAMS WITH ORTHOGONAL LINEAR POLARIZATIONS**

Lian Nedelchev

Institute of Optical Materials and Technologies, Bulgarian Academy of Sciences, Bulgaria

17. **RECOGNITION OF ACTIVITY PATTERNS BY DYNAMIC SPECKLE ANALYSIS**
Elena Stoykova
Institute of Optical Materials and Technologies, Bulgarian Academy of Sciences, Bulgaria
18. **ACCELERATED DYNAMIC SPECKLE SENSING OF DRYING SURFACES**
Elena Stoykova
Institute of Optical Materials and Technologies, Bulgarian Academy of Sciences, Bulgaria
19. **COMPOSITE THIN FILMS OF AZOPOLYMER WITH EMBEDDED GOLD NANOSIZED PARTICLES: EVALUATION OF THE EFFECTIVE COMPLEX REFRACTIVE INDEX**
Nataliya Berberova-Buhova
Institute of Optical Materials and Technologies, Bulgarian Academy of Sciences, Bulgaria
20. **POLARIZATION HOLOGRAPHIC GRATINGS WITH ENHANCED PARAMETERS RECORDED IN AZOPOLYMER BASED NANOCOMPOSITE MATERIALS**
Dimana Nazarova
Institute of Optical Materials and Technologies, Bulgarian Academy of Sciences, Bulgaria
21. **ANISOTROPY INDUCED IN 4-HYDROXY COUMARIN HYDRAZO DYES BY IRRADIATING WITH LASER LIGHT WITH THREE DIFFERENT WAVELENGTHS**
Blaga Blagoeva
Institute of Optical Materials and Technologies, Bulgarian Academy of Sciences, Bulgaria
22. **DIFFRACTION EFFICIENCY AND SURFACE RELIEF OF POLARIZATION HOLOGRAPHIC GRATINGS IN AZOPOLYMER PAZO DOPED WITH TiO₂ NANOPARTICLES**
Georgi Mateev
Institute of Optical Materials and Technologies, Bulgarian Academy of Sciences, Bulgaria
23. **ELECTROCHEMICAL CORROSION BEHAVIOR OF ELECTROLESS Ni-P COATINGS IN ALKALINE AND ACIDIC SOLUTIONS**
Veselina Chakarova
Institute of Physical Chemistry, Bulgarian Academy of Sciences, Bulgaria
24. **ELECTROLESS DEPOSITION OF THIN CHEMICAL NICKEL LAYERS FROM ECOLOGICAL ELECTROLYTE IN THE PRESENCE OF VARIOUS ADDITIVES**
Veselina Chakarova
Institute of Physical Chemistry, Bulgarian Academy of Sciences, Bulgaria

25. **INVESTIGATIONS OF ARTIFICIAL METAMATERIALS AND MULTILAYER NANO-COMPOSITES IN EXTERNAL MAGNETIC FIELD**
Plamen Dankov
Sofia University "St. Kliment Ohridski", Faculty of Physics, Bulgaria
26. **CHARACTERIZATION OF MICROWAVE ABSORBERS, INCLUDING MULTILAYER NANOABSORBERS**
Valda Levcheva
Sofia University "St. Kliment Ohridski", Faculty of Physics, Bulgaria
27. **OPTICAL PROPERTIES OF AZOPOLYMER THIN FILMS DOPED WITH PARTICLES OF A BIOLOGICAL ACTIVE HYDANTOIN BASED NICKEL COMPLEX**
Ani Stoilova
University of Chemical Technology and Metallurgy, Bulgaria
28. **SILVER NANOPARTICLE DECORATED POLYMERS FOR CATALYSIS**
Jakub Siegel
University of Chemistry and Technology, Prague, Czech Republic
29. **THE EFFECT OF THE POSITION AND SHAPE OF THE REACTION VESSEL ON THE TRANSFER OF ULTRASONIC ENERGY FROM THE COUPLING FLUID TO THE REACTION MIXTURE**
Daniela Ghimpeteanu
University Politehnica of Bucharest, Romania
30. **REMOVAL OF METHYLENE BLUE FROM WASTEWATER BY ADSORPTION ONTO OF BRANCHED AMINATED WASTE POLYACRYLONITRILE FIBERS**
Zlate Veličković
Military Academy, University of Defence, Serbia
31. **APPLICATION OF THE GIS FUZZY AHP MODEL FOR IDENTIFYING SUITABLE LOCATIONS FOR HAZARDOUS WASTE DISPOSAL**
Ljubomir Gigović
Military Academy, University of Defense, Serbia
32. **NANOINFORMATIX PLATFORM: DATA AND MODELLING INFRASTRUCTURE FOR THE SAFETY ASSESSMENT OF ENGINEERED NANOMATERIALS USED IN CONSUMER PRODUCTS AND MEDICAL APPLICATIONS**
Danail Hristozov
East European Research and Innovation Enterprise, Bulgaria
33. **THE EVALUATION OF CROSS-LINKER CONTENT IMPACT ON THE SWELLING CAPACITY OF POLY(1-VINYL-2-PYRROLIDONE) HYDROGELS**
Zorica Eraković
University of Nis, Serbia
34. **THE STUDY OF NANOCRYSTALLINE FERRIMAGNETIC SEMICONDUCTOR TRIPLE PEROVSKITE $Sr_3Co_2WO_9$ PREPARED BY SOL-GEL ROUTE**
Igor Djerdj, Jelena Bijelic
University of Osijek, Croatia

35. CERIA-ZIRCONIA SOLID SOLUTIONS AS POSSIBLE CONSTITUENTS FOR THREE-WAY CATALYSTS TOWARDS CO OXIDATION

Dalibor Tatar
University of Osijek, Croatia

36. THE STUDY OF HOMOGENIZATION VALVE VIBRATION

Henryk Komsta
Lublin University of Technology, Faculty of Mechanical Engineering,
Poland

37. OUTLOOK OF SUSTAINABLE APPROACH OF CADMIUM RECOVERY FROM OXIDE BY USING MOLTEN SALTS SLAG

Ervins Blumbergs
Institute of Physics of University of Latvia, Latvia

38. MEASUREMENT AND DIAGNOSTICS OF POWER TRANSFORMER BY FREQUENCY METHODS

Miroslav Gutten
University of Zilina, Slovakia

39. THERMOVISION DIAGNOSTICS OF ELECTRICAL MACHINES

Milan Sebok
University of Zilina, Slovakia

TALK SESSION #2

02:00 – 03:30 PM, 30 August, Flora Expo Center

40. ACADEMIC ETHICS IN THE CONTEXT OF USING TECHNOLOGICAL RESOURCES

Liliana Mata
"Vasile Alecsandri" University of Bacau, Romania

41. INTEGRATION OF AUGMENTED REALITY TECHNIQUES WITH CAX SOFTWARE FOR AIDING A PRODUCT DEVELOPMENT PROCESS

Marcin Januszka
Silesian University of Technology, Poland

42. AN APPLICATION OF AUGMENTED REALITY TECHNOLOGY FOR PRODUCT VISUALISATION DURING MAINTENANCE ACTIVITIES

Marcin Januszka
Silesian University of Technology, Poland

43. AMINO ACID IONIC LIQUIDS (AAILs) BASED ON 1-ALKYL-3-METHYLIMIDAZOLIUM IN AQUEOUS SOLUTIONS AND THEIR PHYSICO-CHEMICAL PROPERTIES

Elena Alopina
G.A. Krestov Institute of Solution Chemistry, Russian Academy of Sciences, Russia

44. FLUORESCENCE MOLECULAR IMAGING IN THE SECOND NIR WINDOW

Takashi Jin
RIKEN Center for Biosystems Dynamics Research, Japan

45. PERSPECTIVES OF ELECTRIC POWER INDUSTRY DEVELOPMENT ON THE EXAMPLE OF THE REPUBLIC OF BELARUS

Alexander Mikhalevich

Institute of Power Engineering, National Academy of Sciences,
Belarus

46. DEVELOPMENT OF KNOWLEDGE AND SKILLS FOR BOTH TEACHERS AND STUDENTS THROUGH EXTRACURRICULAR EDUCATION MATERIALS ON BIOSAFETY AND BIOSECURITY

Anila Mitre

Tirana University, Albania

47. STUDY OF THE ANTIPHOSPHOLIPID SYNDROME IN ALBANIAN POPULATION

Anila Mitre

Tirana University, Albania

TALK SESSION #3

10:00 – 11:30 AM, 31 August, Flora Expo Center

48. INVESTIGATIONS ON THE INFLUENCE OF TEMPERATURE ON THE DEPENDENCE OF INSULATION IMAGINARY COMPONENT OF PERMITTIVITY ON SYNTHETIC ESTER – PRESSBOARD

Paweł Żukowski

Lublin University of Technology, Poland

49. THE ADMITTANCE OF THE COMPOSITE OF ELECTROTECHNICAL PRESSBOARD - SYNTHETIC ESTER - WATER NANOPARTICLE

Marek Opielak

Lublin University of Technology, Poland

50. TANGENT OF THE LOSS ANGLE OF AN ELECTROTECHNICAL PRESSBOARD WITH SYNTHETIC ESTER

Tomasz Kołtunowicz

Lublin University of Technology, Poland

51. INDUCTIVE AND CAPACITIVE ELECTRICAL PROPERTIES OF THE NANOCOMPOSITE $(\text{FeCoZr})_x(\text{SiO}_2)_{(100-x)}$

Vitalii Bondariev

Lublin University of Technology, Poland

52. ANALYSIS OF THE PHENOMENON OF PERCOLATION BY USING HIGH VOLTAGE DISCHARGE IN TWO-DIMENSIONAL SYSTEMS OF TRANSLATION SYMMETRY

Paweł Okal

Lublin University of Technology, Poland

53. ALTERING THE MORPHOLOGICAL AND MECHANICAL PROPERTIES OF POLYHIPE/NANOCLAY COMPOSITES BY USING STATISTICAL ANALYSIS

E. Hilal Mert

Yalova University, Turkey

54. **TAILORING THE MECHANICAL PROPERTIES OF POLYHIPES BY USING MYRCENE**
Burcu Kekevi
Yalova University, Turkey
55. **EFFECTIVE ELEMENTAL BASE OF SWITCHING NEUROSTRUCTURES**
Alexander Sychev
The Embassy of Russia in Latvia, Latvia
56. **ANTIMICROBIAL AND CYTOCOMPATIBLE COMPOSITE COATINGS FROM SUSTAINABLE, LOW-COST BIOMATERIALS FOR BIOMEDICAL APPLICATIONS**
Anca-Lăcrămioara Nicărel
University of Bucharest, Romania
- POSTER SESSION #2**
11:30 AM – 12:30 PM, 31 August, Flora Expo Center
57. **TECHNOLOGICAL REGULATIONS OF APPLICATION OF ELECTROLYTE-PLASMA TREATMENT FOR SURFACES DECONTAMINATION OF NPP REMOVABLE EQUIPMENT**
Petr Nagula
Joint Institute for Power and Nuclear Research Sosny, Belarus
58. **RESEARCH OF THE INFLUENCE OF DEFECTS IN THE HYDRAULIC PATH ON THE MEASUREMENT ACCURACY ELECTROMAGNETIC FLOWMETER**
Maryna Kozel
Joint Institute for Power and Nuclear Research Sosny, Belarus
59. **PHYSIC-MATHEMATICAL MODELING OF TRANSPORT PHENOMENA IN ELECTROLYTES DURING METAL SURFACE DECONTAMINATION BY ELECTROLYTE-PLASMA TREATMENT**
Denis Tretinnikov
Joint Institute for Power and Nuclear Research Sosny, Belarus
60. **GOLD NANOPARTICLES FOR PREPARATION OF ANTIBODIES AND VACCINES AGAINST CORONAVIRUSES**
Lev Dykman
Institute of Biochemistry and Physiology of Plants and Microorganisms, Russian Academy of Sciences, Russia
61. **LAYERED COMPOSITES WITH METAL MATRIX REINFORCED BY OXIDE FIBERS**
Valeriy Korzhov
Institute of Solid State Physics, Russian Academy of Sciences, Russia
62. **ON EFFICIENCY OF MICROSHOCK WAVE BACTERIA TRANSFORMATION**
Svetlana Basakina
N.N. Semenov Federal Research Center for Chemical Physics, Russian Academy of Sciences, Russia
63. **TERPENES LOW VAPOR PRESSURE BY EXPERIMENTAL AND PREDICTIVE METHODS**
Eduardo Cassel
Pontifical Catholic University of Rio Grande do Sul, Brazil

64. **SKIN PERMEATION EXPERIMENTS FOR FRAGRANCE SYSTEMS**
Eduardo Cassel
Pontifical Catholic University of Rio Grande do Sul, Brazil
65. **PRESSURE EFFECT ON HEDYCHIUM CORONARIUM ESSENTIAL OIL EXTRACTION BY STEAM DISTILLATION**
Rubem Mário Vargas
Pontifical Catholic University of Rio Grande do Sul, Brazil
66. **PTEROCAULON POLYSTACHYUM ESSENTIAL OILS OBTAINED BY STEAM DISTILLATION UNDER DIFFERENT PRESSURES**
Rubem Mário Vargas
Pontifical Catholic University of Rio Grande do Sul, Brazil
67. **IMPORTANT FACTORS ON THE SPACING BETWEEN THE DIES AFTER SD DICING TAPE EXPANSION**
Wan-Chun Chuang
National Sun Yat-sen University, Taiwan
68. **EFFICIENT ENGINEERING OF IIOT SYSTEMS BASED ON INTEROPERABILITY STANDARDS**
Mario Thron
Institute for Automation and Communication, Germany
69. **APPLICATION OF COMPUTER VISION METHODS FOR AUTONOMOUS CONTAINER LOADING PROCESS**
Darius Drungilas
Klaipeda University, Lithuania
70. **THE EFFECT OF INTEGRAL STIFFENING ON THE FATIGUE OF THIN-WALLED PLATES SUBJECTED TO SHEAR**
Łukasz Święch
Rzeszow University of Technology, Poland
71. **PHOTOVOLTAIC MODULE STRUCTURE UNDER THE HIGH DC VOLTAGE STRESS**
Vladimír Šály
Slovak University of Technology, Slovakia
72. **CHOSEN VIEWS ON CABLE WITH IMPROVED FIRE PERFORMANCE**
Juraj Packa
Slovak University of Technology, Slovakia
73. **IMMOBILIZATION OF BETA-GALACTOSIDASE ONTO AMINOSILANE MAGNETIC NANOPARTICLES AND ITS HYPERACTIVATION**
Maja Leitgeb
University of Maribor, Slovenia
74. **THE EFFECT OF SUPERCRITICAL CARBON DIOXIDE ON FLOUR QUALITY**
Maja Leitgeb
University of Maribor, Slovenia
75. **THE INFLUENCE OF BORIDING ON THE PROPERTIES OF CEMENTED CARBIDES**
David Bricín
University of West Bohemia in Pilsen, Czech Republic

76. **GEORGIAN NATURAL ANALCIME - BASIS FOR CREATING A NANOCRYSTALLINE BACTERICIDAL SORBENT**
Nato Mirdzveli
Ivane Javakhishvili Tbilisi State University, Georgia
77. **POLYMERIC SUPRAMOLECULAR SYSTEMS FOR DNA TRANSFECTION**
Lilia Clima
"Petru Poni" Institute of Macromolecular Chemistry, Romania
78. **CYCLODEXTRIN INCLUSION COMPLEX OF INDOLIZINYL-PYRIDINIUM SALT AS FLUORESCENT PROBES FOR CELL COMPONENTS STAINING**
Oana-Elena Carp
"Petru Poni" Institute of Macromolecular Chemistry, Romania
79. **IN SILICO ASSESMENT OF THE INTERACTION BETWEEN HUMAN SERUM ALBUMIN AND A CATIONIC DYE LIGAND: AUTODOCK STUDY, MOLECULAR DYNAMICS AND EXPERIMENTAL VALIDATION**
Oana-Elena Carp
"Petru Poni" Institute of Macromolecular Chemistry, Romania
80. **ON THE PHYSICAL PROPERTIES OF INDIUM DOPED ZINC OXIDE AND ALUMINUM DOPED ZINC OXIDE THIN FILMS GROWN BY RADIO-FREQUENCY MAGNETRON SPUTTERING**
Sorina Iftimie
University of Bucharest, Faculty of Physics, Romania
81. **SYNTHESIS AND CHARACTERIZATION OF SOL-GEL TiO₂-BASED MATERIALS USING TETRAETHOXSILANE (TEOS) AND/OR METHYLTRIETHOXSILANE (MTES) AS COUPLING AGENTS**
Anca Dumitru
University of Bucharest, Faculty of Physics, Romania
82. **SYNTHESIS OF TITANIUM NITRIDE VIA NANOCOMPOSITES BASED ON MESOPOROUS TITANIA/ACRYLONITRILE POLYMERS**
Anca Dumitru
University of Bucharest, Faculty of Physics, Romania
83. **ULTRASOUND ACTIVATED HETEROGENEOUS CATALYSTS FOR BIODIESEL SYNTHESIS**
Aurel Diacon
University Politehnica of Bucharest, Romania
84. **ULTRASOUND ASSISTED PIGMENT EXTRACTION FROM TOMATO WASTES AND PROCESS OPTIMIZATION THROUGH FACTORIAL DESIGN**
Alexandru Vlaicu
University Politehnica of Bucharest, Romania

TALK SESSION #4

02:00 – 03:30 PM, 31 August, Flora Expo Center

85. IN-SITU MONITORING ALUMINA DURING ALUMINIUM ELECTROLYTIC PRODUCTION

Andrey Suzdaltsev

Institute of High-Temperature Electrochemistry,
Ural Branch of Russian Academy of Sciences, Russia

86. FULLERENES ROTATIONS IN A FAMILY OF FULLERITES FROM C36 TO C96

Anna Chelnokova

Tomsk State University, Russia

87. A FINITE ELEMENT METHOD FOR PREDICTION OF MACROSEGREGATION WITH SOLIDIFICATION COLUMNAR

Houfa Shen

Tsinghua University, China

88. PULLOUT RESISTANCE OF CRIMPED REINFORCING FIBERS USING COLD-DRAWN NiTi SMA WIRES

Eunsoo Choi

Hongik University, South Korea

89. MICROWAVE AND ULTRASOUND - THE ADVANTAGES AND LIMITATIONS OF COMBINED USE

Ioan Calinescu

University Politehnica of Bucharest, Romania

90. CHALLENGES IN THE SYNTHESIS OF COMPOSITES BASED ON HETEROPOLY COMPOUNDS

Snežana Uskoković-Marković

Department of Analytical Chemistry, Faculty of Pharmacy,
University of Belgrade, Serbia

91. PREPARATION OF ZEOLITE ION EXCHANGERS FROM GEORGIAN NATURAL ZEOLITES

Vladimer Tsitsishvili

Ivane Javakhishvili Tbilisi State University, Georgia

92. APPLICATION OF GEORGIAN NATURAL ZEOLITES FOR PREPARATION OF NEW MATERIALS AND THEIR USE IN ENVIRONMENT PROTECTION

Ketevan Ebralidze

Ivane Javakhishvili Tbilisi State University, Georgia

AWARDING CERTIFICATES

31 August *(after the last presentation is over)*

SOCIAL PROGRAM & CLOSING

1 September

(Poster – Materials, Methods & Technologies 2020, Burgas, Bulgaria)

The study of nanocrystalline ferrimagnetic semiconductor triple perovskite $\text{Sr}_3\text{Co}_2\text{WO}_9$ prepared by sol-gel route

Jelena Bijelić,^a Anamarija Stanković,^a Martina Medvidović-Kosanović,^a Pascal Cop,^b Yu Sun,^{b,c} Ákos Kukovecz,^d Zvonko Jagličić,^{e, f} Sugato Hajra^g, Manisha Sahu^g, and Bernd M. Smarsly^b, Igor Djerdj,^{*a}

a. Josip Juraj Strossmayer University of Osijek, Department of Chemistry, Osijek, Croatia

b. Justus-Liebig-Universität, Physikalisch-Chemisches Institut, Gießen, Germany

c. Key Laboratory for Advanced Materials, Research Institute of Industrial Catalysis, School of Chemistry and Molecular Engineering, East China University of Science and Technology, Shanghai, PR China

d. University of Szeged, Interdisciplinary Excellence Centre, Department of Applied and Environmental Chemistry, Szeged, Hungary

e. University of Ljubljana, Faculty of Civil and Geodetic Engineering, Ljubljana, Slovenia

f. University of Ljubljana, Institute of Mathematics and Physics & Mechanics, Ljubljana, Slovenia

g. Institute of Technical Education and Research Siksha O Anusandhan (Deemed to be University), Bhubaneswar, India

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ABSTRACT:

Polar perovskite materials have attracted extensive attention due to the coexistence of magnetic ground state and semiconductor band gap within the same material. For the first time triple perovskite $\text{Sr}_3\text{Co}_2\text{WO}_9$ has been synthesized in the nanocrystalline form with an average crystallite size of 23 nm using a modified aqueous citrate sol-gel method. The crystal structure of $\text{Sr}_3\text{Co}_2\text{WO}_9$ is cubic at the room temperature, space group $Fm-3m$ with lattice parameter $a = 7.9073(6)$ Å. The formation of $\text{Sr}_3\text{Co}_2\text{WO}_9$ was studied by cyclic voltammetry, UV/Vis spectroscopy and *in situ* X-ray diffraction method subsequently analysed by the Rietveld analysis. The detected hysteresis loops reveal ferrimagnetic ordering with Curie temperature of 144 K. The measured effective magnetic moment of $3 \mu_B$ is close to the expected value for rarely observed intermediate spin $S = 1$ but can also be explained as a combination of HS (40 %) Co^{3+} and LS (60 %). The compound exhibits the semiconducting properties with the optical band gaps equal to 3.52 eV (indirect) and 3.76 eV (direct), respectively, calculated from UV/Vis absorption spectrum using the Tauc method. Semiconducting nature was also confirmed by AC conductivity measurements, which is between 10^{-5} and $10^{-4} \Omega^{-1} \text{cm}^{-1}$. The frequency dependent dielectric constant was explained by employing the Maxwell-Wagner model. The frequency dependent AC conductivity follows the universal Jonscher's power law. This material could be a good candidate for implementation as a constituent for devices where its semiconducting properties would be spin controlled.

The study of nanocrystalline ferrimagnetic semiconductor triple perovskite $\text{Sr}_3\text{Co}_2\text{WO}_9$ prepared by sol-gel route

Jelena Bijelić,^a Anamarija Stanković,^a Martina Medvidović-Kosanović,^a Pascal Cop,^b Yu Sun,^{b,c} Ákos Kukovecz,^d Zvonko Jagličić,^{e, f} Sugato Hajra,^g Manisha Sahu,^g Bernd M. Smarsly^b and Igor Djerdj^{*a}

^a Josip Juraj Strossmayer University of Osijek, Department of Chemistry, Uli. Cara Hadrijana 8/A, HR-31000 Osijek, Croatia

^b Justus-Liebig-Universität, Physikalisch-Chemisches Institut, Heinrich-Buff-Ring 17, D-35392 Gießen, Germany

^c Key Laboratory for Advanced Materials, Research Institute of Industrial Catalysis, School of Chemistry and Molecular Engineering, East China University of Science and Technology, Shanghai 200237, PR China

^d University of Szeged, Interdisciplinary Excellence Centre, Department of Applied and Environmental Chemistry, Rerrich Béla tér 1, H-6720 Szeged, Hungary

^e University of Ljubljana, Faculty of Civil and Geodetic Engineering, Jamova 2, SI-1000 Ljubljana, Slovenia

^f University of Ljubljana, Institute of Mathematics and Physics & Mechanics, Jadranska 19, SI-1000 Ljubljana, Slovenia

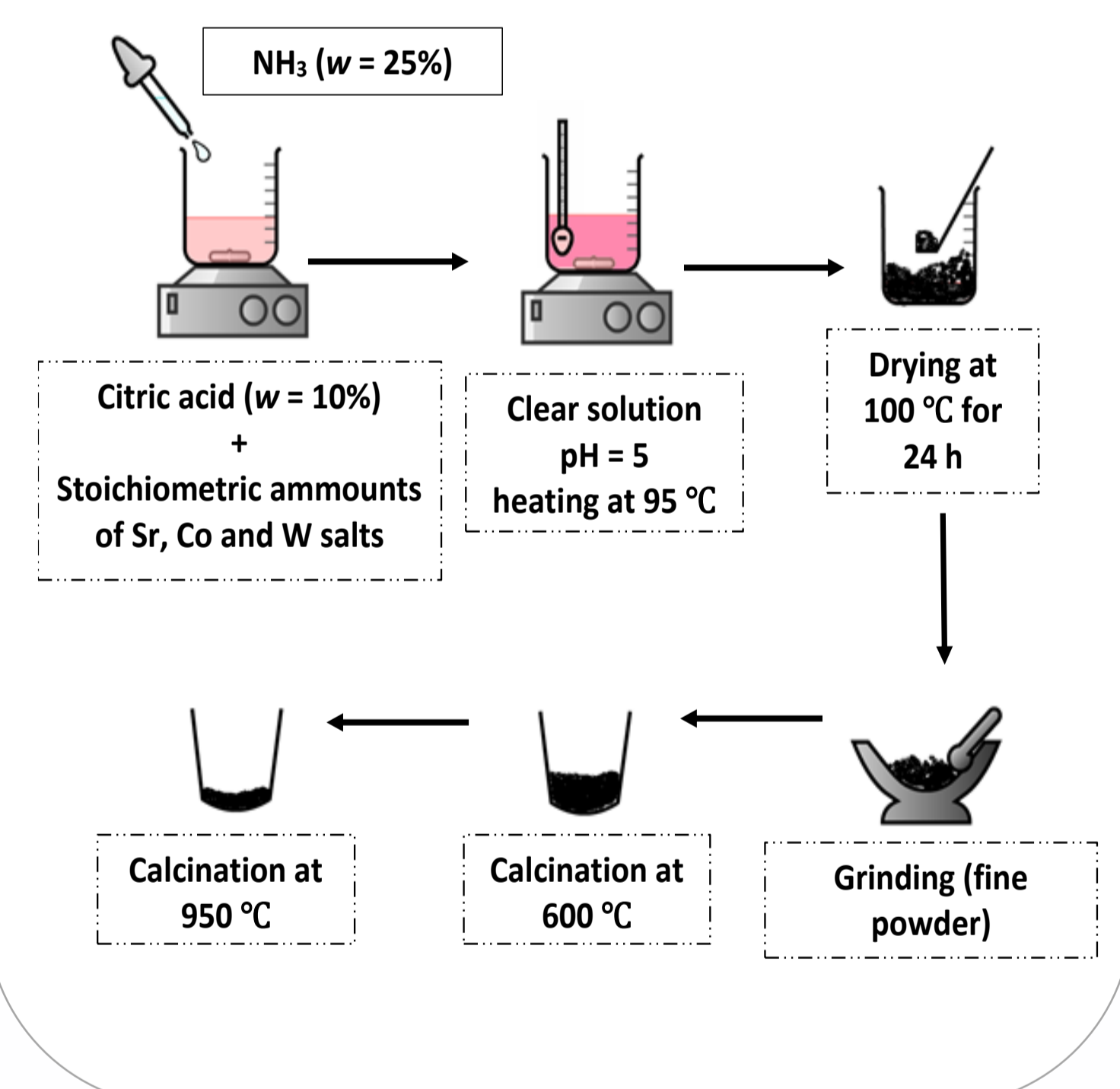
^g Institute of Technical Education and Research Siksha O Anusandhan (Deemed to be University), 751030 Bhubaneswar, India

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INTRODUCTION

Polar perovskite materials have attracted extensive attention due to the coexistence of magnetic ground state and semiconductor band gap within the same material. For the first time triple perovskite $\text{Sr}_3\text{Co}_2\text{WO}_9$ has been synthesized in the nanocrystalline form with an average crystallite size of 23 nm using a modified aqueous citrate sol-gel method. The crystal structure of $\text{Sr}_3\text{Co}_2\text{WO}_9$ is cubic at the room temperature, space group $Fm-3m$ with lattice parameter $a=7.9073(6)$ Å. The formation of $\text{Sr}_3\text{Co}_2\text{WO}_9$ was studied by cyclic voltammetry, UV/Vis spectroscopy and *in situ* X-ray diffraction method subsequently analysed by the Rietveld analysis. The detected hysteresis loops reveal ferrimagnetic ordering with Curie temperature of 144 K. The measured effective magnetic moment of $3 \mu_B$ is close to the expected value for rarely observed intermediate spin $S=1$ but can also be explained as a combination of HS (40 %) Co^{3+} and LS (60 %). The compound exhibits the semiconducting properties with the optical band gaps equal to 3.52 eV (indirect) and 3.76 eV (direct), respectively, calculated from UV/Vis absorption spectrum using the Tauc method. Semiconducting nature was also confirmed by AC conductivity measurements, which is between 10^{-5} and $10^{-4} \Omega^{-1} \text{cm}^{-1}$. The frequency dependent dielectric constant was explained by employing the Maxwell-Wagner model. The frequency dependent AC conductivity follows the universal Jonscher's power law. This material could be a good candidate for implementation as a constituent for devices where its semiconducting properties would be spin controlled.

EXPERIMENTAL



RESULTS AND DISCUSSION

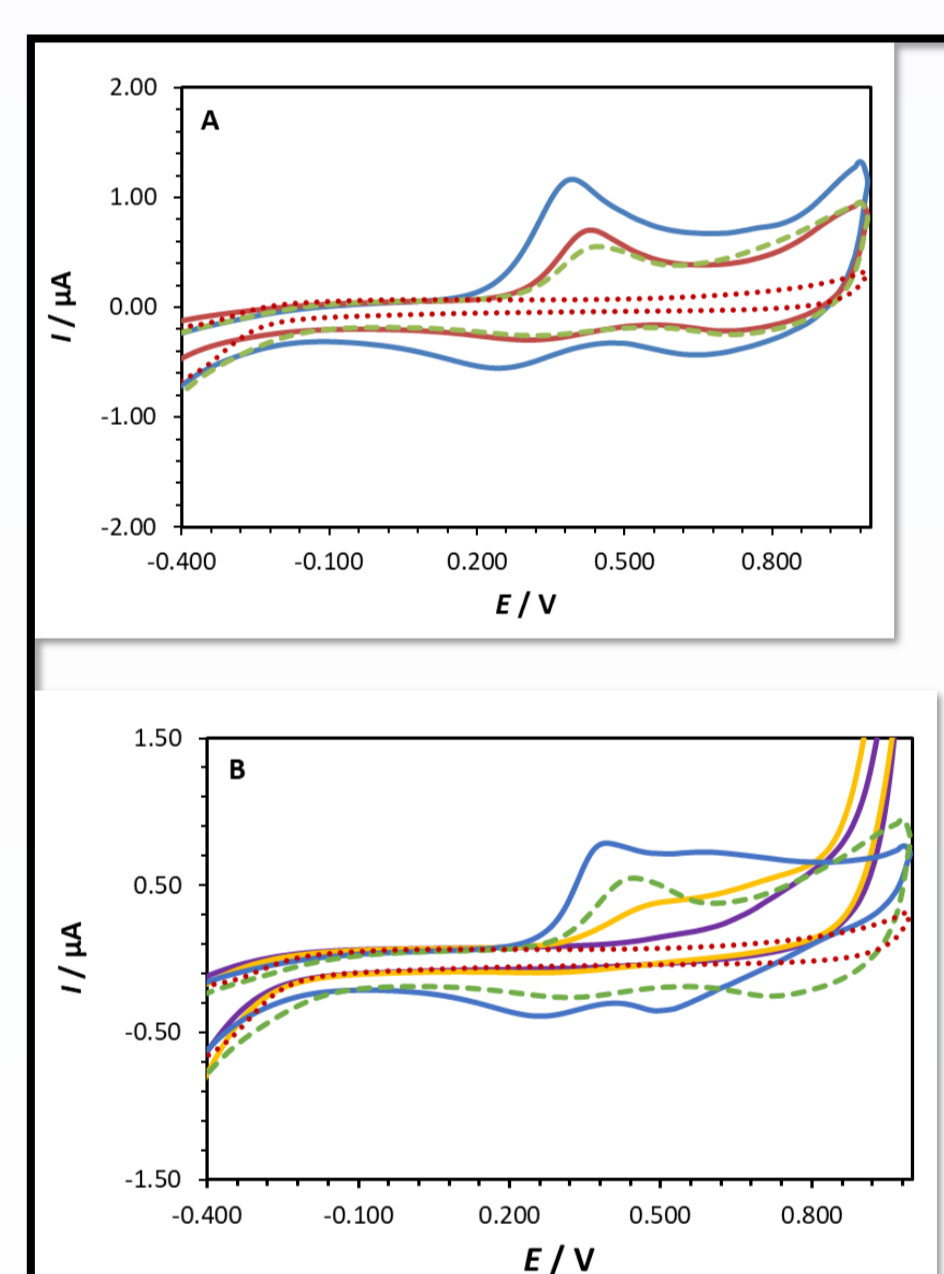


Figure 1. Cyclic voltammograms of blank solution (0.1 M KNO_3 solution) (••••), $\text{Co}(\text{NO}_3)_2$ (—) ($c = 5 \cdot 10^{-3} \text{ mol dm}^{-3}$, $I_s = 0.1 \text{ M KNO}_3$) and: A) Co^{2+} with ammonia in 1:1 (—) and 1:2 (—) ratios, B) Co^{2+} with ammonia in 1:4 (—), 1:6 (—) and 1:8 (—) ratios at a glassy carbon electrode vs Ag/AgCl reference electrode.

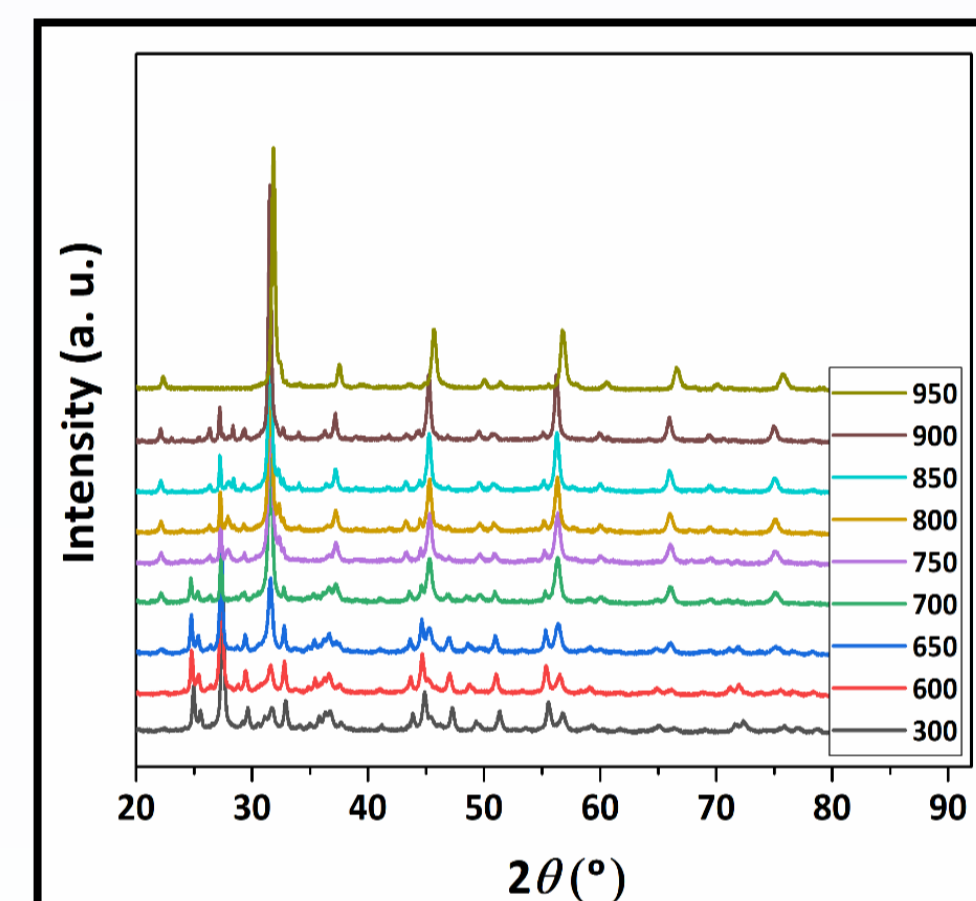


Figure 2. *In situ* XRD patterns of intermediate compounds after the first step of calcination at 600 °C collected from 600 °C to 900 °C compared to the referent phase pure $\text{Sr}_3\text{Co}_2\text{WO}_9$ calcined at 950 °C (pattern collected at room temperature).

Table 1. Summary of the phase compositions obtained by the Rietveld refinement of *in situ* powder XRD patterns collected from 600 °C to 900 °C.

Phase (wt.%)	SrWO_4	SrCO_3	Co_3O_4	$\text{Sr}_3\text{Co}_2\text{WO}_9$	$\text{SrCoO}_{2.5}$	WO_2
temp (°C)						
600	33.6(2)	32.9(3)	22.4(4)	11.1(2)	-	-
650	24.9(2)	25.4(2)	16.9(3)	31.9(2)	-	0.9(1)
700	6.9(1)	15.7(3)	13.7(4)	62.9(4)	-	0.8(1)
750	6.2(1)	-	8.9(6)	71.2(5)	12.9(3)	0.8(1)
800	5.5(1)	-	8.4(7)	70.7(6)	14.6(3)	0.8(1)
850	4.9(1)	-	5.9(5)	74.1(5)	14.0(4)	1.1(1)
900	5.5(1)	-	5.9(4)	80.4(5)	6.4(3)	1.8(1)

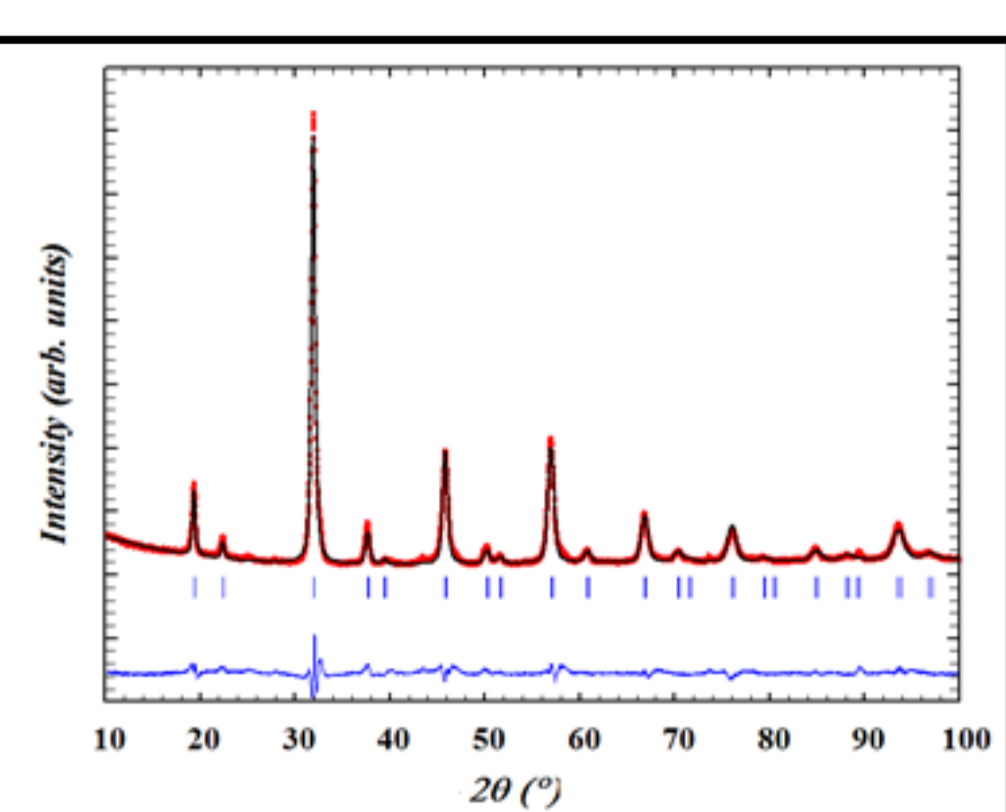


Figure 3. Rietveld output plot of the investigated compound $\text{Sr}_3\text{Co}_2\text{WO}_9$ treated at 950 °C. The observed (red), calculated (black) and difference plot (blue) for the fit to the PXRD pattern is shown along with Bragg reflections of identified phase (vertical ticks).

Table 2. Crystallographic data and refinement parameters obtained from the laboratory X-ray powder diffraction.

Chemical formula	$\text{SrCo}_{2/3}\text{W}_{1/3}\text{O}_3$
Space group	$Fm-3m$
Molecular weight	708.56
Z	8
Crystal system	Cubic
Lattice parameters (Å)	$a = 7.9073(6)$
Cell volume (Å ³)	494.40(2)
Calculated density (g/cm ³)	6.318(6)
Data collection range	10 – 100°
No. of parameters refined	15
Average apparent crystallite size (nm)	23
Average apparent microstrain ($\times 10^{-4}$)	45.377
R_B (%)	4.37
Conventional R_p, R_{wp}, R_c (%)	14.1, 14.8, 5.18
GoF	2.9

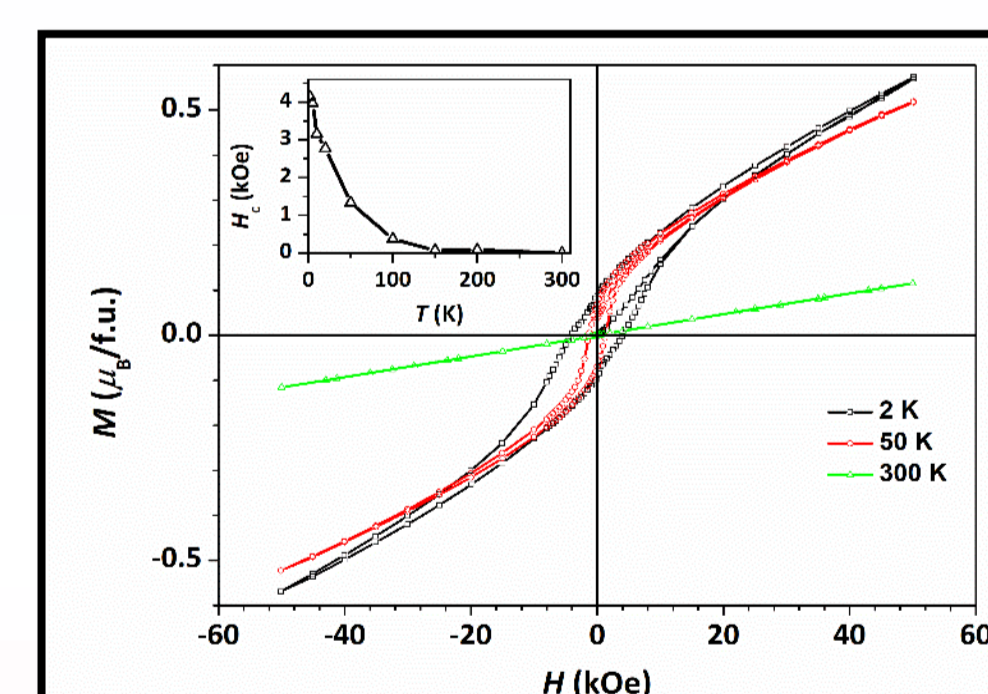
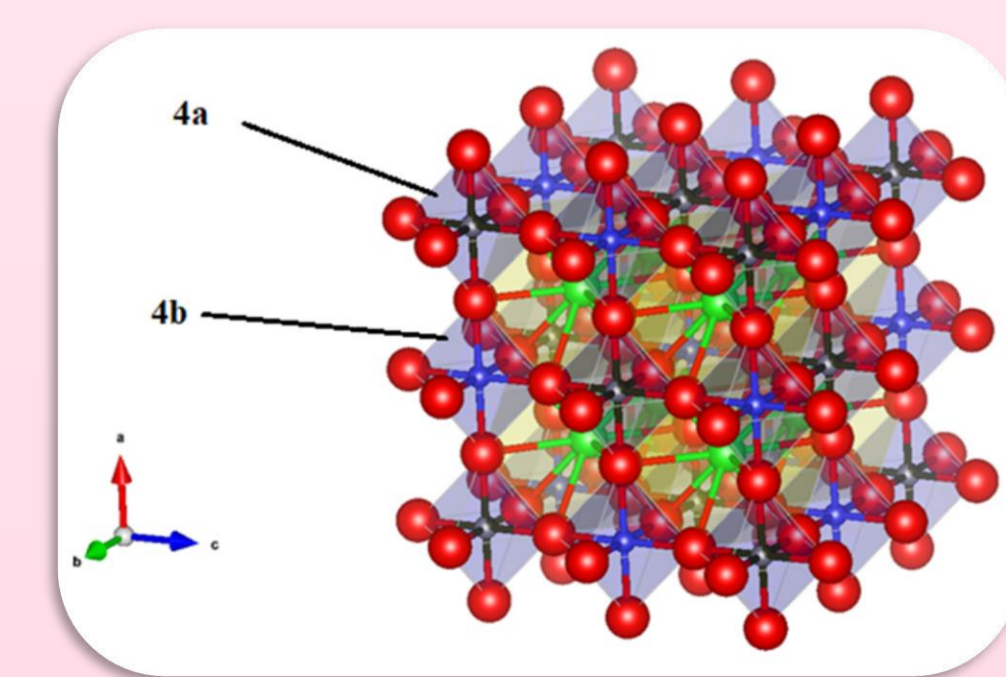


Figure 4. Isothermal magnetization at 2 K, 50 K, and 300 K. Inset: coercive magnetic field as function of temperature. Considering two Co^{3+} ions per formula unit and, as calculated from the susceptibility measurements and obtained effective magnetic moment, only 40 % of them being in a HS state with $S=2$, the saturation magnetization should be of the order of $2 \cdot 0.4 \cdot gS\mu_B \approx 3.2 \mu_B$ per formula unit. The measured remanent magnetization of $0.09 \mu_B/\text{f.u.}$ at 2 K is much smaller, which is in accordance with the proposed ferrimagnetic ordering of magnetic moments

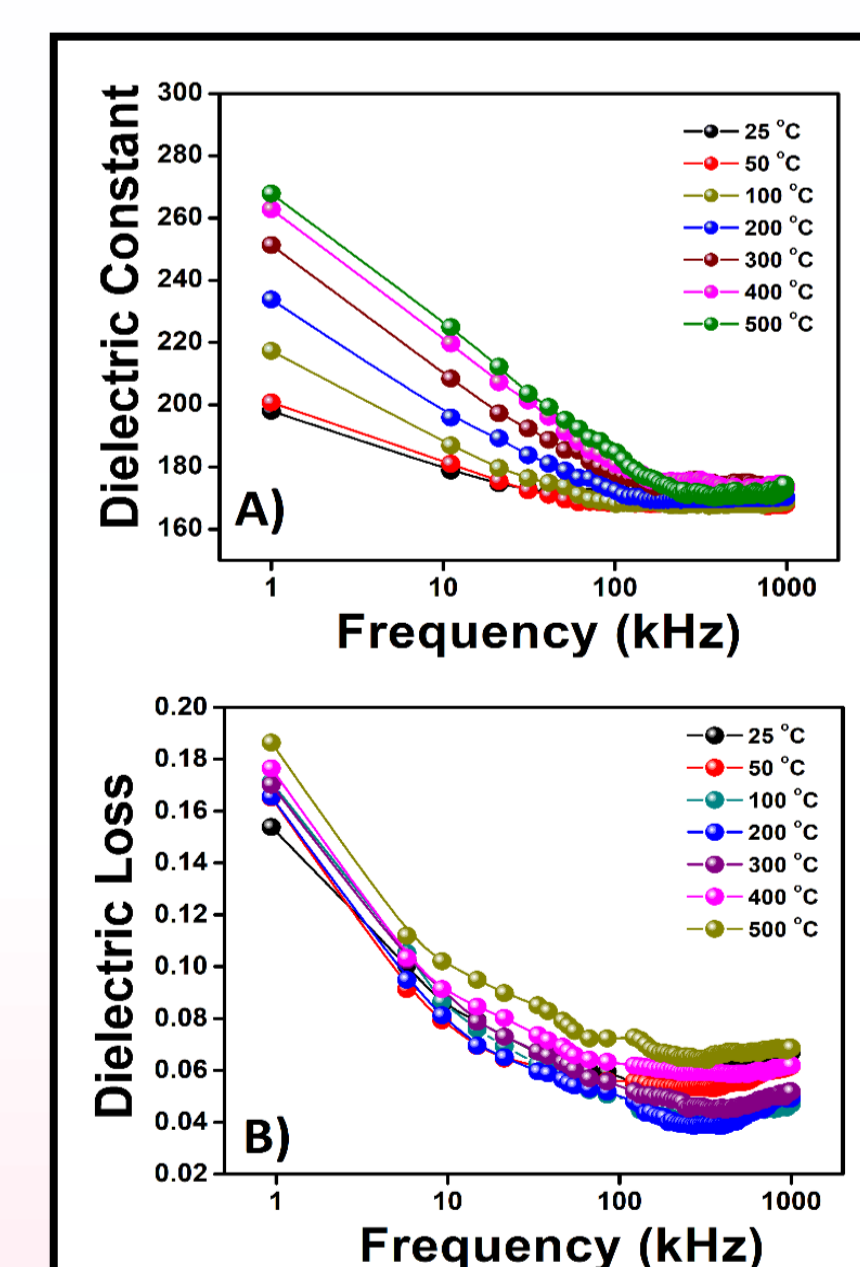


Figure 5. The dependence of A) dielectric constant and B) dielectric loss on frequency of the $\text{Sr}_3\text{Co}_2\text{WO}_9$ pellet sintered at 1250 °C at selected temperatures.

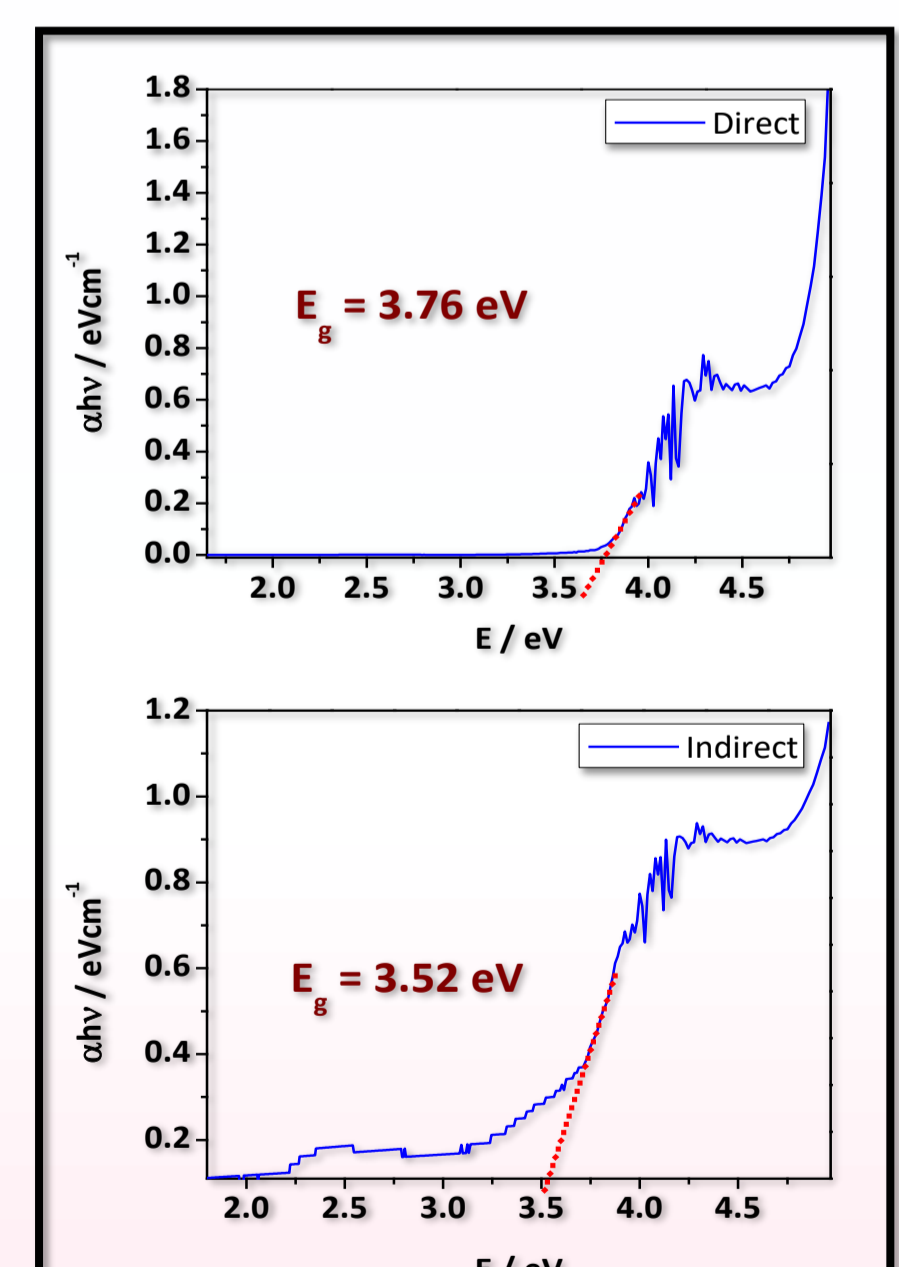


Figure 6. Tauc plot of the direct (A) and indirect (B) band gap of $\text{Sr}_3\text{Co}_2\text{WO}_9$.

CONCLUSIONS

Triple perovskite $\text{Sr}_3\text{Co}_2\text{WO}_9$ (SCWO) has been successfully synthesized for the first time in nanocrystalline form using a high yield (81 %) aqueous citrate sol-gel method. The starting solutions were electrochemically characterized to prove the formation of a Co^{3+} ion from the starting Co^{2+} - containing metal salt precursor. The structural analyses indicate that the obtained phase-pure compound crystallizes in the cubic space group $Fm-3m$ with lattice parameter $a=7.9073(6)$ Å. The microstructural analyses reveal small average crystallite size of 23 nm and moderate microstrain. Magnetic property measurements revealed a ferrimagnetic behavior with Curie temperature of 144 K. Dielectric measurements revealed high dielectric constant ranging from 198 at RT and 1 kHz to 270 at 500 °C (1 kHz) which increases with the frequency. Indirect and direct band gap values of 3.52 eV and 3.76 eV, respectively, reveal a wide band gap semiconducting behavior of this compound.