

Online ISSN

3007-3197

Print ISSN

3007-3189

<http://amresearchreview.com/index.php/Journal/about>

SYNTHESIS OF ALKALI AND TRANSITION METAL SALTS OF BIOLOGICALLY ACTIVE ORGANIC ACIDS TO INVESTIGATE THE BIOLOGICAL ACTIVITIES

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ABSTRACT

The present study reports the successful synthesis and characterization of a series of potassium salts of organic acids (1–6) and their corresponding cobalt carboxylate potassium salts. The transformation from ligands to potassium salts was confirmed through notable changes in physical state, solubility, color, and melting point behavior. While the parent ligands were insoluble in water, their synthesized potassium salts exhibited high aqueous solubility, whereas the corresponding carboxylate salts showed partial or negligible solubility. Distinct color variations were observed between ligands and their potassium salts, further supporting successful salt formation. The melting points of the potassium salts ranged between 200–400°C, generally lower than those of the parent ligands, indicating structural modification.

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Print ISSN

3007-3189

<http://amresearchreview.com/index.php/Journal/about>

Keywords: Potassium Carboxylate Salts; Organic Acid Ligands; Structural Modification

INTRODUCTION

Metallic carboxylate potassium salts are known since 1400 B.C. Lead linolates were first carboxylate potassium salts used in paint industry for mummification. After that with the industry revolution in 1800, manganese carboxylate potassium salts were introduced in paint industry. Metallic carboxylates are stem from ligand known as carboxylic acids. Ligand like carboxylic acids become solubilized in water and gives a hydrated cation and a carboxylate anion. Metal carboxylates are stable potassium salts because carboxylic acids with different co-ordination modes provide them stability [1], [2], [3], [4]. Metal carboxylates have large potential to work as functional material in synthetic chemistry. Metal carboxylates are used as photo oxidative degradation of polymers, rubber adhesion promoter, antitherapeutic agents and as a precursor in catalyst synthesis in supramolecular and tyre industry respectively. Carboxylates are fascinating complex in context to have a wide range of biological and physiological [5]. Humans are at great health risk from last few decades. Pathogenic microorganism causes fatal infections to living organism. These fatal infections are breaking out due to bacteria, viruses and fungus as well. Twentieth century was the peak time of antibacterial drug discovery. In 1960, quinolone and penicillin was introduced. Most of drugs from 1950's is still in use. After that there was not any innovative drug introduced till 21st century. In 2000, a drug named linezolid (carboxylate complex) was discovered and inaugurated in clinical practice [6], [7]. Bacteria has diversified structure resistant towards antibiotics already present in market like quinolone, penicillin etc. Bacteria have tendency to modify their structure and develop shield against drugs for defense purpose. Bacteria are at major advent of many diseases mainly pathogenic bacteria are *E. coli*, *S. auerus* and *C. difficile* etc. Transition metals are biologically active metals, when these metals combine with biologically active organic acid, stable potassium salts are formed. These stable carboxylate potassium salts produce biologically active drugs that are effective against *E. coli*, *S. auerus* and *C. difficle*. Cobalt metal having d^{10} system, with transition oxidation states and is biologically active. Cobalt was reported active against pathogens about sixty years ago. It is the part of vitamin B12 which indirectly regulates DNA synthesis [8]. Cobalt carboxylate potassium salts exhibit antiviral, antiproliferative, antifungal, antioxidant and antibacterial activities. Cobalt potassium salts act as bacteriocidal as well as bacteriostatic agents. Bacteriostatic agents inhibit the growth of pathogen whereas bacteriocidal kills the specified pathogens [9]. The aim of research is to synthesize new potassium salts (pre-cursors) and cobalt carboxylate potassium salts by using biologically active organic acids to synthesis potassium salts that are effective against resistant bacteria and having less toxic effect [8], [10], [13].

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EXPERIMENTAL

All chemicals purchased from Sigma–Aldrich and utilized without decontamination. Infrared spectra were recorded in the range of 4000–400 cm^{-1} , Bruker s-2013 Fourier-Transform Infrared spectrophotometer utilizing OPUS programming. UV–Visible (UV–Vis) spectra of the potassium salts in DMSO were recorded on a Hitachi U-2001 Spectrophotometer. Melting points of potassium salts were recorded utilizing a Bibby SMP10 melting point device and were uncorrected. Values are taken up to 485°C [10], [11].

Synthesis and characterization of potassium salts were done at co-ordination chemistry Lab, PARS Campus, University of Agriculture, Faisalabad. FTIR analysis were done at SNS, NUST, Islamabad and GC university, Faisalabad. Biological activity of potassium salts was checked at pharmacy department of GC university. Potassium hydroxide, Methanol, Chloroform, Silver oxide, Vanilic acid, Adipic acid, Gallic acid, 3,5-Dinitro salicylic acid, 3-Aminobenzoic acid, 4-Nitro benzoic acid etc. Beakers (50 mL, 100 mL, 250 mL), two necked round bottom flask (200 mL), measuring cylinder (10 mL, 1 mL), pipette (10 mL, 1 mL), funnel and stirrer etc. Common methodology was incorporated metal to prepare metal carboxylate potassium salts. Metal carboxylate potassium salts were blended in the response of ligand (ascertained sum from its gram weight) with potassium hydroxide (computed sum as indicated by gram weight of ligand) at room temperature with steady mixing in alcoholic medium. Solution was mixed at room temperature for 60 minutes with magnetic stirrer and little measure of methanol was added. Potassium hydroxide was added by dissolving in least measure of methanol. Potassium carboxylate salt was obtained. Potassium carboxylate salt obtained was separated, after that it was washed with dichloromethane. For the readiness of metal carboxylate overwhelming, particular metal halide was utilized with potassium carboxylate salt; mixing of metal halide suspension was done in presence of methanol. Filtration, washing and drying was done with a specific end goal to isolate unreacted metal halide. At long last, metal carboxylate complex was formed [10].

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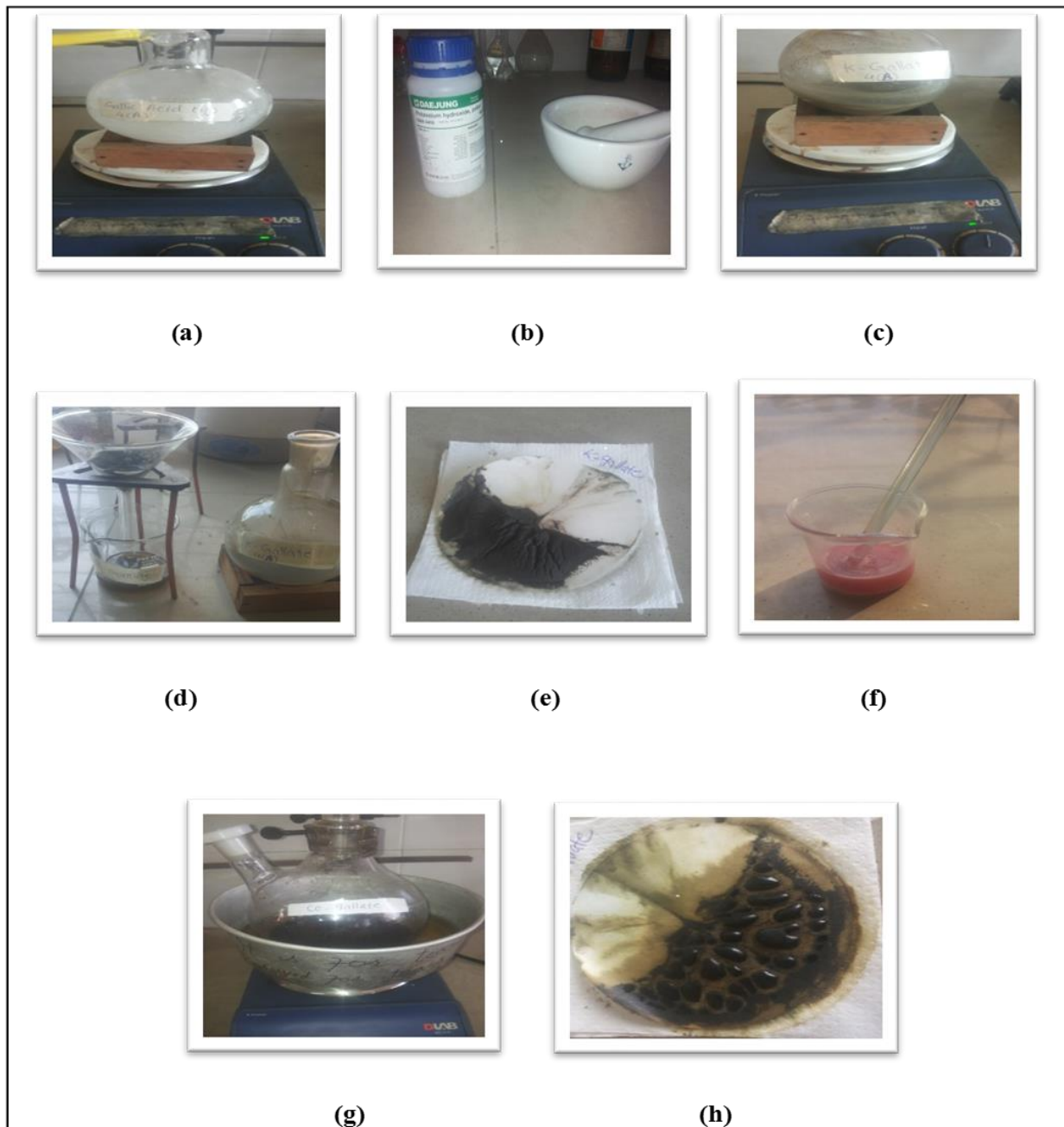


Figure 3.2. (a-h) Schematic diagram of synthesis of cobalt gallate complex.

To characterize sample, melting point was determined. Melting point determination was done with SANYO Gallencamp, Japan at Co-ordination chemistry lab, Pars campus, UAF. For melting point determination, capillary tube was taken. By heating it on flame capillary jet was made. Little amount of sample was inserted in this capillary and inserted it into melting point apparatus. Maximum temperature was taken at about 484.4°C shown in figure 4.. Melting point is noted for all ligands and their respective

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salts. It has shown major differences between their melting points that indicates respective complex is formed [7], [8].



Initial Reading

Final reading

Figure 3.8. (a-b) Melting point determination by GALLENKAMP g-117, Sanyo, Japan at PARS Campus, UAF.

RESULT AND DISCUSSION

The preliminary indications for the successful synthesis of target compounds potassium salts of organic acid (1-6) were the physical states, solubility and a noticeable difference in melting points of ligands, salts and their respective potassium salts. For example, all ligands were insoluble in water while synthesized k-salts from ligands are highly soluble in water and their respective carboxylate potassium salts were insoluble in water some of them complex 4 and 5 were partially soluble in water. Color of the respective salt also turned change ligands of potassium salts 2,3 and 5 are white in color and their respective potassium salts are black, shiny white, pinky respectively. Ligands were in powder form but synthesized cobalt carboxylate potassium salts 2 and 4 were obtained as crystals. Furthermore, melting points of all salts were found in the range of 200-400°C whereas the melting points of cobalt carboxylate potassium salts are less than their salts, indicating the formation of potassium salts [7], [12]. During synthesis of

different potassium salts resulted were obtained which are presented on coming up pages in the form of tables.

Table 4.1 Physical characteristics of Ligands

Ligand	Compound Code	Molecular weight (g/mol)	Color	Molecular Formula	Melting Point
Vanilic acid	1	168.04	Skin	C ₈ H ₈ O ₄	213 °C
Gallic Acid	2	170.12	White	C ₇ H ₆ O ₅	260 °C
Adipic Acid	3	146.14	White	C ₆ H ₁₀ O ₄	153 °C
3,5-dinitro salicylic acid	4	228.12	Yellow	C ₇ H ₄ N ₂ O ₇	182 °C
3-Aminobenzoic Acid	5	137.14	White	C ₇ H ₇ NO ₂	163 °C
4-Nirtobenzoic acid	6	167.12	Brown	C ₇ H ₅ NO ₄	237 °C

Table 4.2 Physical Characteristics of Potassium Carboxylate Potassium salts

Complex Name	Compound Code	Color	Molecular weight (g/mol)	Molecular formula	Melting point
K-valinate	1	brown	176.21	C ₇ H ₅ KO ₃	337°C
K-gallate	2	Dark green	208.21	C ₇ H ₅ KO ₅	413°C
K-adipat	3	Shiny White	184.23	C ₆ H ₉ KO ₄	279 °C
K-3,5dinitro salicylate	4	Yellow	266.21	C ₇ H ₃ KN ₂ O ₇	344 °C
K-3-Amino	5	Brown	175.23	C ₇ H ₆ KN ₂ H ₂ O ₂	

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3007-3197

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benzoate					274 °C
K-Nirtobenzoate	6	Brown	175.23	C ₇ H ₆ KNO ₂	243 °C

Interpretations Using FT-IR spectra

Fourier Transform Infrared Spectroscopy FTIR were done with Thermo logical USA model Bruker SP-6700 at NUST, Islamabad and Bruker SP-1300 at GC University, Faisalabad. The FT-IR spectra were recorded in 4000-400 cm⁻¹ area. Carboxylic acids show a broad -OH band at around 3400 cm⁻¹ which was often suppressed due to either intramolecular or intermolecular hydrogen bondings. These bands did not appear in the FT-IR spectrum of ligands 1-6, indicating the possible intermolecular bonding. However, potassium carboxylate showed a broad peak at around 3370 cm⁻¹ which seemed to be due to the presence of hydrated water molecules. This might be due to the higher affinity of potassium Vanillic acid and its respective salt and complex, potassium carboxylate were analyzed by FT-IR in parallel to observe the differences in their FT-IR characteristic patterns. Figure showed that stretching vibrations appeared for carbonyl (C = O) group in vanillic acid (1706 cm⁻¹), for tetra substituted alkene group (1638 cm⁻¹) and 'c' indicated the presence of a terminal monosubstituted alkene (891 cm⁻¹). The FT-IR patterns of potassium carboxylate showed some distinct changes compared with the FT-IR spectral features ligands having COOH as a functional group. For example, the vibrational bands at 'a' in acid ligand (1706 cm⁻¹) shifted to 'a' in potassium carboxylate salt (1529 cm⁻¹) and some new bands 'd' also appeared. These signals a' & d are caused by the formation of carboxylate heads (-COO⁻ K⁺) in potassium carboxylate salt [3], [10]. The vibrational bands remained the same on salt formation. The stretching vibrational bands in the highlighted region 'e' in Figure 1b represents the alkyl groups (CH₃ & CH₂) in the ligands and respective potassium carboxylate which remained same in both spectra.

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3007-3197

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3007-3189

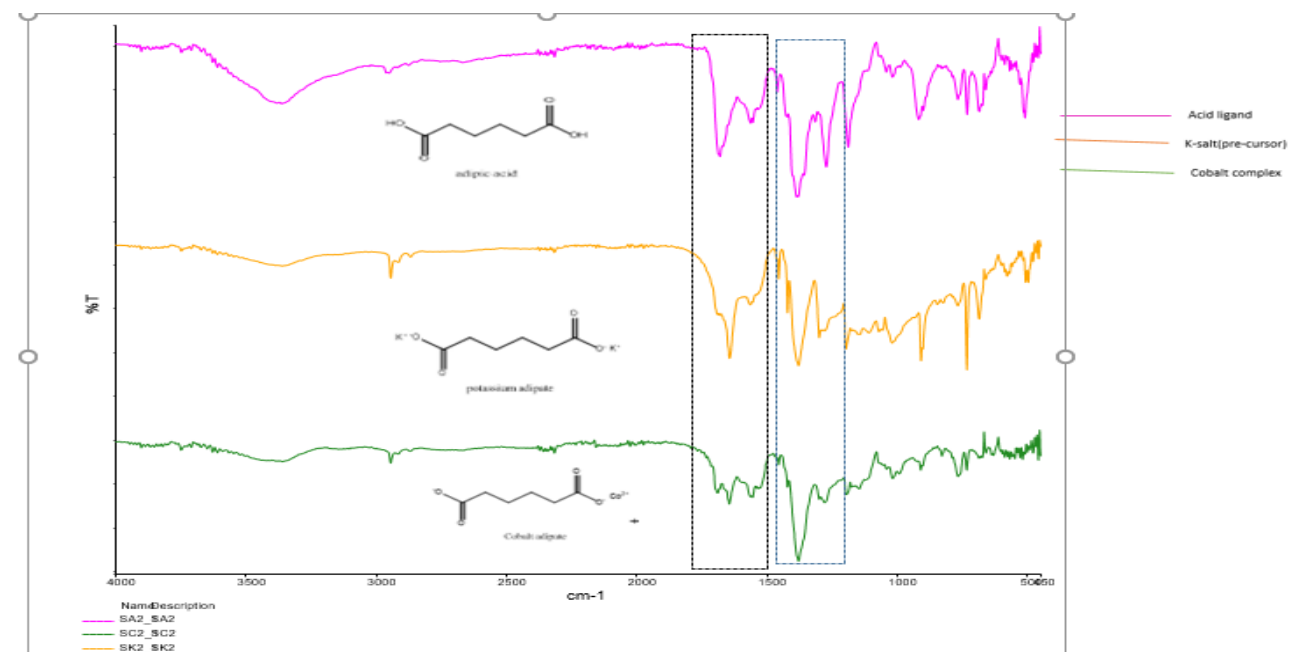
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Figure 3.1 Spectra of acid and salt comparison of adipic acid vs k-salt

FT-IR spectra of adipic acid, potassium adipate and respective complex cobalt adipate display the spectral changes after replacing the proton of acetate head in adipic acid by potassium ion in potassium adipate. Most significant changes are the dislocation of (C=O) vibration in adipic acid from position α to α' and in complex we can observe the change at α'' , it confirms the formation of new complex [4], [8].

FT-IR spectra of 3-aminobenzoic acid, potassium k-3-aminobenzoate and respective complex cobalt-3-aminobenzoate display the spectral changes after replacing the proton of acetate head in 3-aminobenzoic acid by potassium ion in potassium-3-aminobenzoate. Most significant changes are the dislocation of (C=O) vibration in adipic acid from position α to α' and in complex we can observe the change at α'' , it confirms the formation of new salt [5], [11].

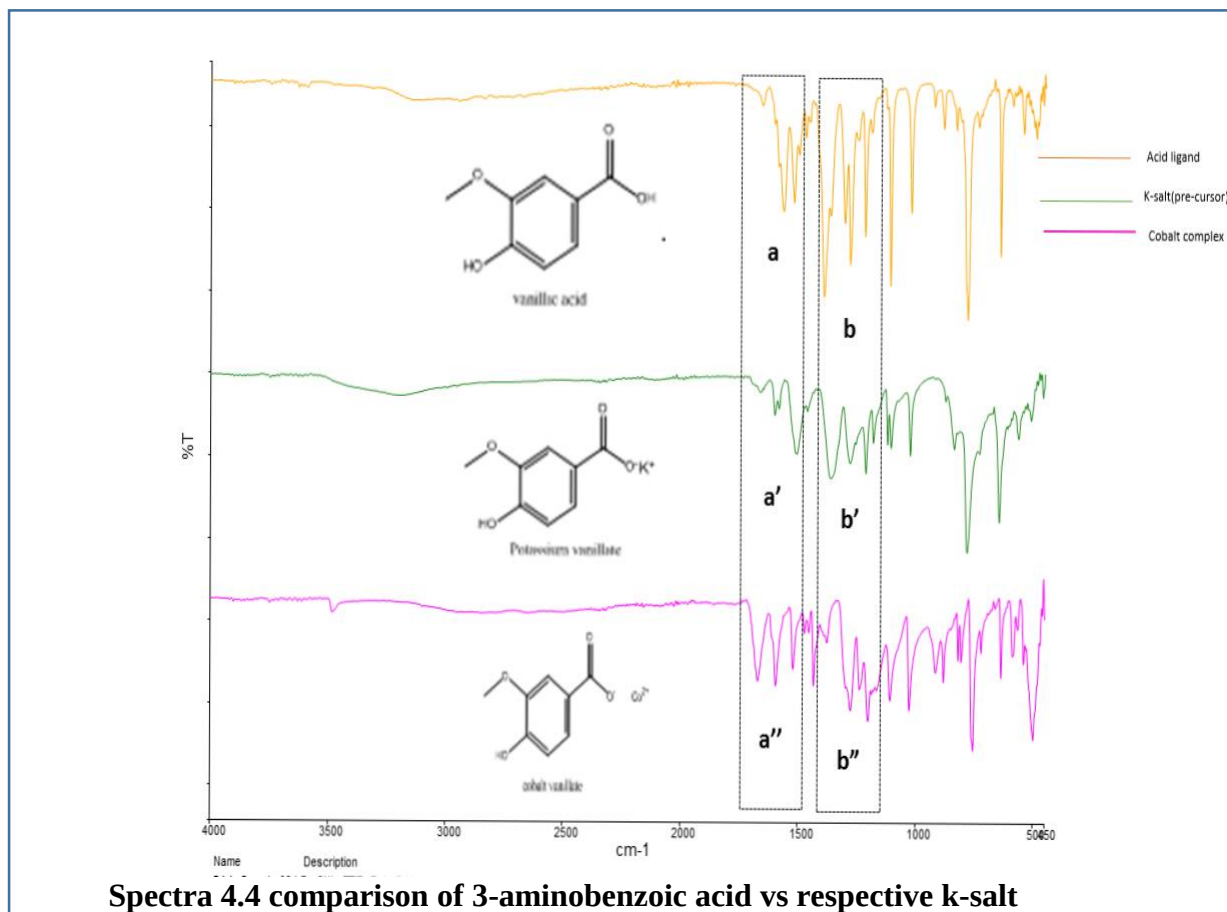
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Spectra 4.4 comparison of 3-aminobenzoic acid vs respective k-salt

The fluorescence properties of metal carboxylate potassium salts have been important to research groups for more than thirty years. Some preparatory fluorescence studies were completed on a determination of the current cobalt carboxylates keeping in mind the end goal to examine the impact that coordination to cobalt metal that focuses on the fluorescence of the free ligands. The UV-Vis assimilation range was recorded to recognize the most extreme ingestion wavelength of every carboxylate complex. The absorption peaks at ca. 365 nm in the ingestion range are related to vibrational levels of the state while the top at ca. 260 nm are related to the state¹⁵³, 165 nm. These ingestions emerge from the excitation of electrons into the orbital of the anthracene moiety from different levels inside the ground state. Fluorescence spectra were then recorded and contrasted with that of metal free [14], [15].

CONCLUSION

Coordination chemistry of 3d metal potassium salts has become great interest from many scientist groups all over the world during last couple of decades. There are various causes for this, containing the esthetically attractive structures that a lot of such molecular potassium salts possess. On the other hand, the major two causes of interesting deep interest in the 3d metal potassium salts are their relevance to nanoscale magnetic materials and to chemistry of bioinorganic.

Online ISSN

3007-3197

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