

Prussian blue essay examples

[Environment](#), [Pollution](#)



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Introduction

Prussian blue was discovered by Diesbach and Dippel between 1704 and 1707 in Berlin and was initially used as a synthetic pigment. The new pigment of Prussian blue was less expensive but readily produced unlike the other blue pigments initially used during the blue color paintings. 1

Evidential document provides that Prussian blue was produced in Berlin between 1708 to 1716 by Frisch and Diesbach. Selling of Prussian blue was initially done by Frisch. Dippel also produced the compound while he was in Netherlands until 1714. Frisch and Diesbach attempted to keep the secrecy of the production of Prussian blue due to its robust success in the market.

However, once the secret was disclosed in 1724, scientist commenced research and production in different countries in Europe 1. Prussian blue is an exceptionally stable compound. The industrial application of Prussian blue as a pigment is still widely recognized. While the Prussian blue compound has been in the field of science for 285 years and has attracted the attention of researchers ever since, there are innovative and promising areas of its application that are currently being explored. Prussian blue is still applied as

a pigment. It has also been applied in sensor to poison antidotes and electromagnetics 2.

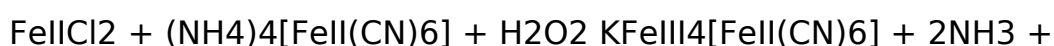
Structure of Prussian blue

The Prussian blue pigment has been described as type II mixed-valence transition metal complex 2. Prussian blue is hydrated iron (III) hexacyanoferrate (II) complex that is composed of variable 2. The pigment varies depending on the condition of preparation, method of manufacture, precipitation conditions of sodium, potassium, or ammonium ions and varying degree of water. 3 The alkaline metal-free formula of the pigment is $\text{Fe}^{\text{III}}_4[\text{Fe}^{\text{II}}(\text{CN})_6]_3 \cdot x \text{H}_2\text{O}$ (iron (III) hexacyanoferrate (II), where $x = 14-16$). Studies from neutron scattering and X-ray diffraction have shown that the pigment has a face-centered cubic lattice structure. In the structure, the metal sites are occupied by iron (III) and iron (II) in alternating positions 3. The iron metals bridge the cyano groups in the form of a rectangular array that provides a three-dimensional polymeric network 4. Within the structure, a quarter of C, Fe II and N are vacant. The spectroscopic and Mossbauer research provides that low-spin iron (II) gets octahedrally coordinated to the six cyano groups containing carbon atoms. Likewise, the high-spin iron (III) is octahedrally coordinated to the nitrogen atoms as well as to the coordinated oxygen in water molecules that occupies the free N sites. Hence, the mix provides an average composition of $\text{Fe}^{\text{III}}_4 \text{N}_4 \cdot 5 \text{O}_1 \cdot 5 \cdot 4$. The pigment structural element framework consists of a sequence FIII-N-C-Fell, and the intense color stems from the electronic transition existing between the twin valence states of iron. Figure 1 below shows the structure of Prussian blue.

Figure 1: The lattice structure of Prussian Blue with K⁺ and water molecules in the interstitial spaces.

Synthesis of Prussian blue

The production of Prussian blue can either be direct or indirect. The indirect method discussed here is a one-step process. It refers to a two stage process based on the reaction between a ferrocyanide salt and a ferrocyanide salt such as potassium hexacyanoferrate (II) and iron (II) salt that gives a white insoluble product referred to as the Berlin white (iron (II) hexacyanoferrate (II), M₂FeII[FeII(CN)₆], where M= sodium, ammonium, or potassium depending on the reagents used. The product further goes under treatment using a powerful oxidizing agent, for example, chromate or chlorate to produce the soluble Prussian blue [5, 6, 7]. The generation of Prussian blue from a mixture of ammonium hexacyanoferrate (II) and iron (II) chloride, using hydrogen peroxide as an oxidant is summarized as follows;



2H₂O

physical Properties of Prussian blue The hexacyanometalates reactions involving the trivalent molecular complexes and metal ions coordinated to two tmphen ligands leads to the formation of a series of heterometallic, homogenous cyanide-bridge clusters. Cyanide-bridge clusters pentanuclear were experimentally prepared to determine the properties of Prussian blue 7. The experiment involved combining of [M, III(CN)₆]³⁻ anions with mononuclear complexes of MII ions with two capping tmphen ligands. The clusters used in the experiment consisted of trigonal bipyramidal (TBP) core and three other M III ions in the axial position and M II ions in the equatorial

positions. According to the results, the compounds $[\text{Zn}(\text{tmphen})_2]_3[\text{Cr}(\text{CN})_6]_2$, $[\text{Zn}(\text{tmphen})_2]_3[\text{Fe}(\text{CN})_6]_2$, and $[\text{Fe}(\text{tmphen})_2]_3[\text{Fe}(\text{CN})_6]_2$ are crystallized and isostructural in the monoclinic space group $P2_1/c$. However, $[\text{Fe}(\text{tmphen})_2]_3[\text{M}(\text{CN})_6]_2$ ($\text{M} = \text{Cr}, \text{Fe}$) (4) crystallizes in the enantiomorphic space group $P3221$. Likewise, the magnetic properties of $[\text{Zn}(\text{tmphen})_2]_3[\text{Fe}(\text{CN})_6]_2$ and $[\text{Zn}(\text{tmphen})_2]_3[\text{Cr}(\text{CN})_6]_2$ provide a reflection of the individual contributions of $[\text{Cr}^{\text{III}}(\text{CN})_6]^{3-}$ and $[\text{Fe}^{\text{III}}(\text{CN})_6]^{3-}$ ions 8-10. Mentioning physical properties, researchers established that Prussian blue electrochemically reduced and oxidized. During the cycling from the negative to positive potential, oxidation of $[\text{Fe}^{\text{III}} \text{Fe}^{\text{II}}(\text{CN})_6]$ or transformation of Prussian white to $[\text{Fe}^{\text{III}} \text{Fe}^{\text{II}}(\text{CN})_6]$ (PB) was observed at 0.4 V. Marshall indicated that the potassium chloride electrolyte solutions and the redox process were accompanied by a concomitant potassium ion out flux/influx in the Prussian film on the electrode for the compound electro-neutrality 9, 10. The Fe II ions in the compound of $[\text{Fe}(\text{tmphen})_2]_3[\text{Fe}(\text{CN})_6]$ provides a high gradual spin induced by temperature transition between the low spin and high spin. This has been determined by the combination of magnetic measurements, Mossbauer spectroscopy, and single-crystal X-ray studies. Furthermore, the investigation of the properties of $[\text{Fe}(\text{tmphen})_2]_3 [\text{M}(\text{CN})_6]_2$ ($\text{M} = \text{Cr}, \text{Fe}$) using similar methods and by the IR spectrometry provides that the linkage of cyanide isomerism occurs during the formation of clusters. Therefore, the magnetic behaviour of $[\text{Fe}(\text{tmphen})_2]_3[\text{M}(\text{CN})_6]_2$ ($\text{M} = \text{Cr}, \text{Fe}$) compound is determined by the weak ferromagnetic coupling between the equatorial diamagnetic Fe II ions and the axial Cr III centers. Therefore, the Mossbauer

spectra collected under highly applied field have provided the direct observation experiment of the uncompensated density of spin at diamagnetic metal ions that enables bridging of paramagnetic metal ions.

Figure 2: structure of Prussian blue. Source <http://www.chemexplore.net/mixed-valent.htm>

Application of Prussian blue in Health for Treatment of the Internal Radiocesium Contamination Radiocesium has been found to be a potential source of radioactivity used by terrorists as a radiological dispersal device (RDD) or dirty bomb due to its cheap availability, pharmacokinetics and high dose rate radioactivity when ingested or inhaled. The insoluble Prussian blue (Radiogardase) is a binding agent to cesium in the gastrointestinal track after inhalation or ingestion of cesium in bile by the liver. Therefore, it reduces both gastrointestinal reabsorption and primary uptake of foods. Thompson and colleagues indicate that the binding agent has demonstrated to be a dramatically effective reducing agent for the residence time for radiocesium in the body alongside a consequent reduction of effective dose resistance 11. The application of Prussian blue for the treatment of internal radiocesium has gained approval by the U. S food and drug administration. Furthermore, the healthcare providers have used an agent to issue Prussian blue prescriptions to relevant beneficiaries exposed to radiocesium exposure. The therapy guidelines of Prussian blue prescription follow the immediate administration as soon as possible after ingestion or inhalation of radiocesium. Yet, the internal contamination quantitative determination might be unavailable with the first 24 hours of the terrorist incident incorporating radiocesium. Consequently, a quantitative assessment of the

internal contamination likelihood is instrumental in determining the timing of the treatment. The individuals that might have been close to the incident have a greater chance of contamination. Therefore, because Prussian blue is widely recognized, the treatment of presumptively victims exposed to radiocesium is not contraindicated although the use of Prussian blue agent judiciously is advised to guarantee the required adequate supply to provide support for sustained victims that have high chances of internal contamination. In a nutshell, definitive internal contamination diagnosis is significant to provide treatment for the victims. Role of Prussian blue as a die. Prussian blue provides unique pigmentation that enables its use as a die. The agent has been applied in the field of electrostatic assembly for creating self-assembled films. The agent used in electrostatic self-assembly depends on the electrostatic interactions between nanoparticles instrumental for building thin films. The procedure relies on the state of art approach that involves the basic requirements to have polyelectrolyte pairs alongside an interesting functional group. The substrate used to provide the chemical treatment is usually negative. Therefore, it is dipped into a solution containing one polycation for a predetermined time. In most circumstances, several minutes are adequate for establishing stability in polymer configuration on the substrate 12. Thereafter, the support is washed using pure water to eliminate any loose nanoparticles that might be held to the polymer by weak Van der Waals forces. The mechanism of using Prussian blue in thin film work by charge compensation that gets provided by the absorbing molecules has been identified. While it might be observed that the oppositely charged polymers could provide a local neutralization, the effects

of surface force measurement have proved that there is a generation of excessive density of charge absorption step. Franz documented the description of the step as starting off using stoichiometric pair of ion at the first absorption stage and then followed by the restructuring of the subsequent absorption of the polymer 13. The staining properties of Prussian blue provide visibility of ions using formalin fixation that appears to bring about elevated percentage of color. Likewise, the role of Prussian blue has provided significant method of stained film in bone marrow and blood. A simple staining procedure involves non-hemoglobin iron in the erythrocytes, macrophages, and normoblasts among other cells that contains specific iron in old or new cellular fluid films 13-14. . The method mentions the use of Prussian blue reagent to provide counterstain where no separate decolonization is significant. The obtained representations resemble the original preparations with an exception that the iron stands out as a valid blue-green material 15-16. Conclusions Prussian blue got discovered by Dippel and Diesbach in 1706 in Berlin. Documented references provide that the traces of Prussian blue have grown significantly with research on its properties and applications in various industries. The unique properties of Prussian blue alongside other transition of metal hexacyanoferrates that are significant with reference to the existing materials concerning their analytic uses require mentioning. Firstly, the metal hexacyanoferrates enable the potentiometric development and amperometric sensors for non-electroactive cations. Prussian blue is widely considered the most beneficial low-potential hydrogen peroxide transducer among the hexacyanoferrates and all over the systems. The sensitivity and specific activity of Prussian blue are widely used

as hydrogen peroxide transducer. Particular significance and application of Prussian blue is expected to be introduced in certain clinical settings for diagnosis of conditions where selectivity and sensitivity and the possibility of miniaturization are needed. Essentially, research on non-invasive monitoring of chemistry of blood and brain are the future prospects of Prussian blue application.

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