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The Role of White Phosphorus in Two World Wars

White phosphorus, one of the common allotropes of the element phosphorus, is highly reactive and toxic. This extremely reactive material burns intensely and can ignite cloth, fuels and other volatile items. It is highly hazardous for human health and can cause significant injury. Despite the hazards, it assists in the production of phosphoric acid that is used to manufacture many household products, personal-care products and soft drinks. Also, the reactivity of white phosphorus makes it a valuable constituent of ammunition. This explosive substance has been utilized as an anti-personnel munition weapon in many conflicts including World War I and World War II.

Properties of White Phosphorus

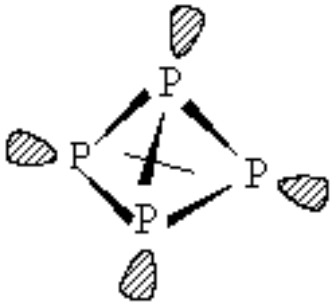

Figure 1 Molecular Structure of P4

Elemental phosphorus appears primarily in two allotropic forms: red phosphorus and white phosphorus. Red phosphorus is a safe material that does not ignite at room temperature; it is made from heating white phosphorus at high temperatures. White phosphorus generally appears in the form of a waxy-yellow transparent solid with a garlic smell (Irizarry). It is never found freely in nature due to its high reactivity. White phosphorus has a P_4 tetrahedron structure where all atoms are bound by a single bond (Figure 1). It is the least stable and most reactive form compared to phosphorus' other allotropes. White phosphorus is usually stored in water. On exposure to air, white phosphorus ignites:

$$P_4 + 5O_2 \rightarrow P_4O_{10}$$

It is oxidized by atmospheric oxygen into phosphorus pentoxide, emitting a faint green glow and demonstrating its high volatility and pyrophoricity, i.e. its ability to self-ignite. It is also highly toxic, causing destruction of inner tissue and eventually death upon oral intake of as little as 15 mg (Irizarry).

Applications of White Phosphorus

Although white phosphorus is dangerous, it is used in making many everyday products, ranging from Coca Cola to toothpaste (Pike). White phosphorus is not freely found in nature, it is mined from apatites, tri-calcium phosphate rocks. About 50% of the phosphorus-mining industry is located in Arab nations. Because phosphorus is in such high demand, the supply of phosphorus is estimated to deplete within 345 years. The current price is near $45 dollars per lb. White phosphorus is used to synthesize phosphoric acid which is put into fertilizers, food additives, pesticides, fireworks and cleaning compounds. Concentrated phosphoric acid has become central to agriculture because it fertilizes soils. White phosphorus is useful as a water softener as it cleans pipes thoroughly and prevents corrosion. The applications of white phosphorus are extensive in everyday life.

In addition to its practical applications, white phosphorus, often referred to as "Willy Pete", has mainly been used for military purposes. It is used in bombs, artillery, mortars, grenades, smokescreens, missiles and tracers. As an incendiary, white phosphorus burns intensely and can ignite almost any volatile substance. When used in short-range missiles, white phosphorus burst into flames upon impact. As a weapon, phosphorus can cause significant injury or death. It causes painful chemical burns in humans. Because white phosphorus is highly lipid soluble, it delays the healing time of wounds. Also, white phosphorus is highly useful as a smoke agent, causing an instant cloud of smoke, within a fraction of a second, upon impact. The smoke obscures enemy vision and assists in hiding troops and equipment from detection. Smoke agents are often propelled as hand grenades or by artillery. Upon impact, they oxidize with air and create a flame, emitting a hot dense smoke over the local area. White phosphorus is an effective weapon with many applications.

History

In 1669, a German alchemist, Hennig Brand, attempted to create the philosopher's stone[1] from urine. He was convinced that the key to turning metals to gold was found in urine (Advameg). Brand attempted to synthesize a compound by purifying and heating urine; he

1. The philospher's stone is a legendary alchemical stone capable of turning metals into gold.
2. The Fenians belonged to the Fenian Brotherhood whose goal was to rally for an independent Irish Republic.

obtained an inorganic phosphate, a white material that spontaneously caught fire and glowed in the dark when exposed to air. This slow-burning material was white phosphorus. His method of synthesis was copied and reproduced by many scientists. In the 19th century, Fenian arsonists[2] prepared a solution of inorganic phosphates in carbon disulfide solution. When the solution evaporated, the phosphorus compound would burst into flames and ignite in the carbon disulfide fumes. This was the first recorded usage of white phosphorus as an incendiary known as Fenian Fire.

White phosphorus was widely used in World War I. In 1916, the British army introduced the first WP (white phosphorus) grenades. It was used as a smoke screen to conceal troop movements when invading an enemy position. It was also used in tracer bullets; later, this technology was expanded into a special type of bullet that was directed at hydrogen-filled zeppelins in the air. The impact of white-phosphorus bullets readily ignites the flammable hydrogen, creating quick-burning flames, destroying the zeppelins and its valuable cargo. Not only was it used on the battlefield; disgruntled workers created WP solutions for incendiary purpose in riots over the legitimacy of conscription laws. Germany also utilized white phosphorus to some extent. However, the Germans had few munitions that were made of white phosphorus as it was highly volatile and difficult to contain and transport. Overall, WWI set the stage for the use of phosphorus in later conflicts.

During WWII, WP was extensively used in numerous military items including mortar bombs, shells, missiles and grenades. It was vital in the war effort. Not only did it cause terrible damage, it had a psychological effect on the enemy instilling fear and disillusion. In 1940, when Britain was on the verge of invasion, a material similar to Fenian Fire was suggested for defense. This material was "Grenade, No.76" which consisted of white phosphorus in carbon disulfide solution similar to Fenian Fire. These improvised anti-tank weapons were hastily prepared and distributed into the field to counter the impending German invasion. However, its use was considered very dangerous and rarely used.

During the American invasion of Normandy in 1944, 25% of the mortars used by American troops were white phosphorus grenades were instrumental in clearing enemy positions, breaking up German infantry attacks and creating havoc within enemy troops. In the 1944 liberation of Cherbourg, the 87th battalion laid siege to the city, firing 11,899 white phosphorus

rounds. As the war progressed, there was increased use of WP incendiaries upon civilian populations and targets of military importance. Although WP was used by Axis forces, it was not heavily emphasized. Instead, they turned to mass aerial raids, bombings and heavy artillery. U.S. troops took full advantage of WP incendiaries despite the risk by integrating WP tactics into their battle strategy. Where once the use of WP was considered dangerous to both user and victims, it now became commonplace in war. WP incendiaries were extremely effective and instrumental in the Allies' victory against the Axis.

White phosphorus has become commonplace in more recent war efforts, including the Iraq War. The main purpose of white phosphorus was for screening and illumination purposes. Most white phosphorus munitions were fired in a round-about manner over enemy positions to flush out enemy insurgents. Once the enemy was in the open, they were decimated by high-explosive rounds. This tactic was widely used in the invasion of Fallujah in Iraq, where there were high concentrations of enemy insurgents. It proved to be an effective and versatile munition (Pike). Not only was WP used to flush out insurgents, it was also a psychological weapon; troops planted trench lines and spider holes with white phosphorus, creating confusion and damage among the enemy.

However, there is questionable legitimacy of the use of WP as an incendiary due to the large number of civilian casualties. The military insists that these munitions are a legitimate tool for purposes of marking and screening.

White phosphorus is not banned by any treaty when used as a smoke agent. However, as an incendiary, it is deemed by the "Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons" as excessively injurious, causing severe burns to the victim (Pike). White phosphorus as an incendiary is regulated by multiple international laws. However, there is no explicit treaty banning its use. The U.S. retains the ability to employ these weapons on high-priority military targets.

White phosphorus is an example of an important chemical that helped to shape the course of history. Not only is it useful for production of everyday products, it is also versatile and effective in war. The use of white phosphorus in ammunitions and smoke agents helped American troops win decisive victories during the 1944 Normandy Campaign, and in the invasion of Fallujah in Iraq. The efforts of various scientists working to develop white

phosphorus into a versatile weapon contributed greatly to the success of the American troops in various conflicts.

Literature Cited

Advameg. Phosphorus. *Chemistry Explained*; Mar 20 2010, Advameg.

Irizarry, Lisandro; Williams, Mollie V. CBRNE- Incendiary Agents, White Phosphorus. *Emedicine* [Online] **2009**.

Pike, John. White Phosphorus (WP). http://www.globalsecurity.org/ (accessed Mar 23 2010); Global Security, 2009.

Shellswell, Steve. Phosphorus, the Element and Hydrides. http://www.everyscience.com/Chemistry/Inorganic/Group_15/a.1279.php (accessed Mar 21 2010); Everyscience, 2004.

Wikipedia contributers. White Phosphorus. http://en.wikipedia.org/w/index.php?title=White_phosphorus&oldid=350982775 (accessed Mar 23, 2010); Wikipedia, The Free Encyclopedia