Explosives are materials which, when suitably initiated, result in the rapid release of energy. Detonation of the solid explosive generates expanding hot gases. This expansion creates a shock wave, which exerts high pressures on the surroundings, causing an explosion. Explosives generally have high nitrogen and oxygen contents, which aid the formation of gaseous products, like carbon dioxide, carbon monoxide, oxygen, nitrogen and water vapors.

The first explosive in all probability was “black powder”, also known as gunpowder, invented accidentally in 220 BC. Since then explosives have been an integral part of the ancient civilized society as well as modern world. In 1846, an Italian professor Ascanio Sobrero discovered liquid nitroglycerine. He soon became aware of the explosive nature of nitroglycerine and discontinued his investigations. Later a Swedish inventor, Immanuel Nobel, developed a process for manufacturing nitroglycerine. Since then more than 300 different kinds of explosives have been discovered and used in various formulations for civilian and military applications (Alexander, 1998).

Based on their purpose, energetic materials can be classified as a) propellants, b) pyrotechnics and c) explosives. Propellants and pyrotechnics release their energy through relatively slow deflagration processes, often taking several seconds to achieve complete combustion. Explosives, on the other hand, release their energy on microsecond timescale. Propellants are most widely used for gun and rocket propulsion application including various missile systems. The major constituents are nitrocellulose (NC) and nitroglycerine (NG). Pyrotechnic compositions are based on reducing agents (also called fuels), oxidizer components, binders and other ingredients to generate certain effects like heat/hot particles/flame, generation of gas/smoke, and light of different colors and noise such as a loud bang/whistling sound.
Explosives can be subdivided into two classes: primary and secondary explosives.

Primary explosives: These are most frequently based on heavy metal salts. They are used in low quantities in detonators to convert a certain input stimulus, such as fire, friction, impact or electricity into a detonation. This detonation is taken up by booster explosives, which amplify the detonation and transmit it further to the main charge. The main primary explosives are lead azide, lead trinitroresorcinate (lead styphnate), and tetrazolyl guanyltetrazene hydrate (tetracene) etc.

Secondary explosives: These explosive are relatively insensitive to shock, friction and heat as compared to primary explosives. These are used as booster explosives and main charges explosives. Booster explosives are based on methyl-2,4,6-trinitrophenylnitramine (Tetryl), pressed Trinitrotoluene (TNT) or Petnaerythritoltetranitrate (PETN) or hexahydro-1,3,5-trinitro-1,3,5-triazone (RDX). Main charge explosives are responsible for the final effect. Traditional Main charge explosives can be very different and their composition depends strongly on their application. High-performance metal accelerating applications are often based on octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine or cyclotetramethylene tetranitramine (HMX also called High Melting Explosive) and a binder system. The amount of binder can be as low as 5%. On the other hand, blasting explosives can be very heterogeneous, for example ammonium nitrate (AN) is used as an oxidizer for a liquid fuel oil (Akhaven, 1998).

Some of the powerful explosives such as TNT, PETN, RDX and HMX are extensively used for military applications as main charge explosives. A new generation of nitramine explosive, 2,4,6,8,10,12-hexanitrohexazaisowurtzitane (CL-20 or HNIW), has recently been developed and has undergone initial testing, where it was found to be 1.4 times more powerful than HMX.

Practically all countries are engaged in the production and processing of virtually all kinds of explosives ranging from gun-powder to the most powerful explosive HMX. All explosives and formulations mainly contain organic nitro compounds such as TNT, RDX also known as ‘Hexogen’ and
HMX also known ‘Octogen’, produced in thousands of tons world over. After production of these high explosive (HE) they may be used in powder form as initiating compositions (e.g. PETN) and can also be processed to produce several compositions such as Composition B (RDX/TNT 60:40), octol (HMX/TNT 70:30), Plastic Bonded Explosive called PBX (HMX or RDX with various binders NC, NG, Estane, Viton etc.) required for filling in various ammunitions.

The production involves several stages of hazardous chemical reactions and processes to produce desired quality and quantity of pure explosives. The further processing i.e. making of castable explosive compositions, casting into moulds, machining to desired size and shape, making PBX molding powder, pressing and subsequent machining leads to generation of large quantity of waste of these hazardous explosives.

Unfortunately, mass production and processing over the last century has generated enormous amount of waste of these compounds. For obvious reasons, there are virtually no reports are available on the amount of waste generated during production and processing of explosives by various countries. It is anticipated that the annual waste is in millions of tons finally discharged to various water bodies. At Department of Energetic Materials Pantex Plant, USA 45,000 kg (approximately) of HEs from nuclear weapons disassembly are burned annually (Patterson and Phelan, 1993). In year 1992, about 56,000 metric tons (80% of the US Department of Defense’s annual demilitarization) of explosive were destroyed using open burning/open detonation (OB/OD) technologies. This has led to extensive contamination of environment including land and water bodies, which now requires remediation. Even underground water is reported to be contaminated with these compounds.

Traditional treatments of toxic ammunition wastes (including HEs production/processing waste) by OB/OD, adsorption onto activated carbon, photo oxidation, etc. are costly, damaging for the environment and in many cases practically infeasible. Further due to environmental concerns, however, these technologies are expected to be banned soon. Even after conventional treatment contamination persists in environment. By and large explosive
compounds are not only recalcitrant but also toxic as well as mutagenic to microbes, animals and plants. The explosives present in contaminated sites (production units, explosion sites, disposal of partially treated effluent etc.) have been reported to get into plants and animal lives. Consumption of contaminated plants/animals can cause severe hepatic problems in humans (Angela, 1999).

United States Environmental Protection Agency (USEPA, 1988a; 1988b) has listed seven nitro-substituted explosives, including TNT and RDX, as priority pollutants, and is known to cause unconsciousness and epileptiform seizures in humans and is considered a possible carcinogen (Lachance et al., 1999). HMX has been listed by the EPA as a contaminant of concern and classified as class D carcinogen. Lifetime health advisories of 2 μg of TNT per liter in drinking water and a water-quality limit of 105 μg of RDX per liter have been recommended.

The toxicity of TNT has been reported since the First World War among English ammunition workers. TNT exposure can cause headaches, skin irritation, weakness, cataracts, anemia, and liver injury in humans (Hathaway, 1985) and is reported to be mutagenic (Padda et al., 2003). From laboratory studies TNT, RDX, and HMX have been found to be toxic for most classes of organisms, including bacteria, algae, plants, earthworms, aquatic invertebrates and animals including mammals and humans. HMX has adverse effects on the central nervous system (CNS) in mammals (McLellan et al., 1988a).

In order to treat the explosive wastes from production and processing stage, (before releasing to environment) base hydrolysis appears to be a safe, simple and inexpensive method for converting energetic materials into non-energetic materials. Many energetic materials can be hydrolyzed with aqueous sodium hydroxide or ammonia at temperature ranging form 60-150°C. Products from base hydrolysis need to be further degraded using biotreatment or supercritical water oxidation. Base hydrolysis of HEs can produce a variety of non-energetic materials including: salts of nitrite, nitrate, and organic acids; and nitrous oxide, ammonia, and nitrogen gases. But the time required for complete destruction is four to five hours at atmospheric
pressure, and the effluent further generated needs to be treated before releasing to environment.

Investigation is required to find alternate techniques for base hydrolysis, which can reduce time and eliminate the effluent completely. For this the detailed chemical and thermal characteristics of nitramine explosive needs to be evaluated. The present technologies including alkaline hydrolysis and molten salt oxidation alone cannot ensure complete neutralization; the biological treatment combined with these technologies can ensure complete eco-friendly disposal. Further, to treat contamination of firing sites, where remaining explosive enters into environment, biological treatment is only alternative. Therefore, there is a considerable interest in developing cost-effective, eco-friendly chemical and biological alternatives.