***Polymers used as binder in solid propellants***

**Solid propellants** are mainly used in gun and rocket propulsion applications. They are very energetic and produce high temperature gaseous products on combustion. The high material density of solid propellants leads to high energy density (The energy produced by a unit mass of a propellant is called its energy density) needed for producing the required propulsive force. Propellants in onboard rocket are burned in a controlled way (deflagration) to produce the desired thrust. A solid propellant consists of several chemical ingredients such as oxidizer, fuel, binder, plasticizer, curing agent, stabilizer, and cross-linking agent. The specific chemical composition depends on the desired combustion characteristics for a particular mission. Solid propellants are often tailored and classified by specific applications such as space launches, missiles, and guns.

The desirable characteristics for a solid propellant are high specific impulse, predictable and reproducible burning rate and ignition characteristics, high density, ease of manufacturing, low cost, and good aging characteristics. In safety point of view propellants should produce low-smoke exhaust and not be prone to combustion instability. In addition, they should have adequate thermo physical and mechanical properties over the intended range of operating and storage conditions.

SOLID Propellants are typically classified as homogeneous or heterogeneous, according to their chemical composition and physical structure. The former contain fuels and oxidizers, which are chemically linked at the molecular level. The ingredients of homogenous propellants are: nitramines (RDX), azides (GAP, BAMO, AMMO), nitrate esters (NG, NC, BTTN, TMETN, DEGDN), or nitrates (ADN, AN). The heterogeneous (composite) include fuel and oxidizers, which are mixed physically. The main ingredients often used are oxidizers such as AP, AN, and KN, and fuels such as HTPB, HTPE, and CTPB

**Ingredients of solid propellants**

**Oxidizer**

Oxidizers are principle ingredients, which produce the high energy on combustion. One of the most commonly used oxidizers is Ammonium Perchlorate. AP dominates the oxidizer list because of its good characteristics that include compatibility with other propellant ingredients, good performance, and availability, low cost and smokeless and non-toxic exhaust

**Metal fuel**

Metal fuels such as aluminium and boron are frequently added to propellant mixtures. Aluminium, one of the widely used metal additives, is used in the form of small spherical particles (5–60 ) in a wide variety of solid propellants. Aluminium particles usually comprise 14–20% of the propellant weight. Addition of metal fuel enhances the heat of combustion, propellant density, combustion temperature, and hence the specific impulse.

**Binder**

Binders provide structurally a matrix in which solid granular ingredients are held together in a composite propellant. The raw materials are liquid prepolymers or monomers. The binder impacts the mechanical and chemical properties, propellant processing and aging of the propellant. Binder materials typically act as a fuel, which gets oxidized in the combustion processes. Commonly used binders are HTPB (hydroxyl terminated poly butadiene) and CTPB (carboxyl terminated polybutadiene). Sometimes GAP (azidepolymer) is also used as energetic binder, which increases the energy density and performance of the propellant. HTPB has been abundantly used in the recent years, as it allows higher solid fractions (total 88–90% of AP and Al) and relatively good physical properties

**Modifier or Catalyst**

A burning-rate catalyst helps to increase or decrease the propellant burning rate. Substances such as iron oxide increase the burning rate, while lithium fluoride decreases the burning rate.