# WHY DO EXPLOSIVES EXPLODE?

"Why does an explosive explode?"
Well, Nitrogen is an inert gas and enters into chemical bonds with great difficulty and remains there with reluctance. In other words the Nitrogen in a molecule introduces an element of instability to the molecule and, given the right stimulus, the bonds are easily broken thus releasing the stored energy therein. The instability produced by the presence of the Nitrogen is absolutely essential otherwise the substance could not be shocked into exploding. **This is why explosives explode,** because of the presence of that instability. The Nitrogen provides another very important function. They keep the oxidisers and oxidisees apart (if the chemists will allow me to get away with these terms)

The Nitrogen is usually introduced by way of the action of Nitric Acid ($KNO_3$) on other chemicals such as Cellulose, Toluene and Glycerine etc. This is where the names come from, TNT tri**nitro**toluene, NG **nitro**glycerine, NC **nitro**cellulose and so on. (This isn't strictly accurate chemically speaking)

Of course it does not follow that all explosions are the result of rapid oxidation. Some explosives contain no oxygen at all e.g. Lead Azide ($PbN_3$) and Acetylene. These explosions are simply the decomposition of the chemical into its constituent parts. The instability in the molecule is created by, (what else?) those Nitrogen atoms.

It is an interesting aside to consider physical as compared to chemical explosions. Liquid carbon dioxide can be used as an explosive by being stored in very strong steel containers under high pressure and then, by heating an element inside the container make the container explode. Carbon dioxide is normally a fire retardant. Water is also a fire retardant yet if confined and superheated it can produce some spectacular explosive effects. Anybody who introduces water in or near molten metal discovers this effect very smartly. Under the right circumstances you can even get dust to explode such as when the dust in a grain silo achieves the right proportions in the air to produce an explosive. You only need a spark.

Even glass can be rendered explosive by rapidly chilling drops of molten glass. A skin is thus formed on the outside of the drop and each layer cools inward and shrinks. Because the outer layer has retained the original heated size (because of the speed of the cooling) the inner layers of the drop can't fill the interior space and the drop finishes up with a vacuum inside and a great deal of tension in the skin of the drop. Breaking the skin causes the drop to explode violently as it resumes its proper size. These drops are known as "Rupert Drops" or "Bologna Phials"

THE NITRO GROUP

As noted above the introduction of Nitrogen atoms into otherwise stable chemicals produces instability, which is the key to achieving an explosion. The weak bonds at the Nitrogen/carbon and Nitrogen/oxygen interfaces cause the instability. This suggests another definition of an explosion:

"The rapid liberation of gaseous Nitrogen from organic combination"

## AVAILABLE ENERGY

Because of the introduction of the Nitro group into the molecule the actual amount of energy available to perform work has been reduced. This is because each carbon atom requires two oxygen atoms for complete combustion and every two hydrogen atoms require only one oxygen atom for complete combustion. Also, because the explosive process takes place inside the molecule, no atmospheric oxygen can be used. Therefore, by introducing that Nitro group we have changed the chemical proportions for efficient combustion to those proportions necessary for an unstable substance capable of being exploded. Thereby reducing the efficiency and power.

| CHEMICAL | C | H | O | N | HEAT OF COMBUSTION AS CAL PER GRAMME |
|---|---|---|---|---|---|
| GLYCERINE $C_3H_8O_3$ | 39% | 9% | 52% | - | 4315 |
| NG $C_3H_5O_9N_3$ | 16% | 2% | 63% | 19% | 1905 (56% less energy) |
| TOLUENE $C_7H_8$ | 91% | 9% | - | - | 10150 |
| TNT $C_7H_5O_6N_3$ | 37% | 2% | 42% | 19% | 3616 (65% less energy) |

The table above shows that explosives are not some immensely powerful chemical source but are in fact quite inefficient (chemically speaking). They merely have two things in their favour. They are self-contained and their action is very rapid.

Coal, Oil, Petrol and Kerosene are much more efficient in terms of energy released, but they all require atmospheric oxygen and a long time frame over which to liberate that energy. On the moon Coal and Petrol have no value at all, whereas TNT and smokeless powder will quite readily perform their allotted task in that airless environment.

With tongue in cheek one might also offer another definition of an explosion……..

"A loud noise accompanied by a rapid going away of things from where they were,"