HOW “GREEN” IS YOUR MANUFACTURING PROCESS

Mervyn D Traut

MD Traut Consulting
SAFEX Expert Panel Member
trautmd@telkomsa.net

“Green” issues, relating to how the explosives industry can make raw materials products, waste, waste disposal and infrastructure “greener” by applying simple logic/basics, are dealt with.
The Kyoto Protocol and other national environmental agreements will soon put pressure on countries and industry to meet the caps or quotas for greenhouse gas emissions. Industries that fail to meet the demands will soon find themselves being non-competitive and unable to meet their customers’ demands.
The explosives industry is a “carbon hungry” one and it is incumbent on this industry to be introspective and find ways of reducing its carbon footprint.
Some ways in which this can be done are discussed and include and focus on, the use of renewable energy, energy efficiency, the efficient use of water and power, the “greening” of buildings, waste reduction and treatment, the use of “green” raw and other materials, toxic substance reduction, waste treatment and air quality improvement. The sustainability of these is also discussed.
The issues above are discussed giving a general perspective and then the focus is placed on the Explosives industry.

WHY “GREEN”?

The term “Green manufacturing processes” refers to processes that aim towards lessening the impact on the environment and as an ideal support sustainable development.

SUSTAINABLE DEVELOPMENT

Environmental sustainability is the process of making sure current processes’ interaction with the environment are pursued with the idea of keeping the environment as pristine as naturally possible.
An "unsustainable situation" occurs when natural capital (the sum total of nature's resources) is used up faster than it can be replenished. Sustainability requires that human activity only uses nature's resources at a rate at which they can be replenished naturally. Inherently the concept of sustainable development is intertwined with the concept of carrying capacity. Theoretically, the long-term result of environmental degradation is the inability to sustain human life. Such degradation on a global scale could imply extinction for humanity.
The table below gives a simply overview of the principles:

Consumption of renewable resources	State of environment	Sustainability
More than nature's ability to replenish	Environmental degradation	Not sustainable
Equal to nature's ability to	Environmental equilibrium	Steady state

replenish		economy
Less than nature's ability to replenish	Environmental renewal	Environmentally sustainable

Background

Burning of fossil fuels is a major source of industrial greenhouse gas emissions, especially for power, cement, steel, textile, fertilizer, ***EXPLOSIVES*** and many other industries which rely on fossil fuels (coal, electricity derived from coal, natural gas and oil). The major greenhouse gases (GHG) emitted by these industries are carbon dioxide, methane, nitrous oxide, hydro fluorocarbons (HFCs), etc, all of which increase the atmosphere's ability to trap infrared energy and thus affect the climate and climate change.
In an environmentally- minded business environment, customers will always look for and in fact quite often demand greener business practices. Companies feel pressure from their competitors that have already taken proactive steps towards environmental improvements in their production processes. These companies benefit at two levels in that they have an image which encourages consumers to buy their products and although adopting these policies takes an initial investment it frees up more resources to develop initial methods for reducing waste, saving them both energy and money in the long run.

Over and above what seems at present to be a voluntary effort on the part of many companies, pressure will be brought to bear by governments where they are not already doing so, in what is believed to be the “not too distant future”. At present this is prevalent in the developed countries, 170 of them, who have signed the Kyoto Agreement. Others will follow and as is commonly known, the key country still to make the commitment is the USA.

The concept of carbon credits came into existence as a result of increasing awareness of the need for controlling emissions. The IPCC (Intergovernmental Panel on Climate Change) observed that

“*Policies that provide a real or implicit price of carbon could create incentives for producers and consumers to significantly invest in low-GHG products, technologies and processes. Such policies could include economic instruments, government funding and regulation*”

Since the United Nations Framework Convention on Climate Change (UNFCCC) came into force, the parties have been meeting annually at what is known as the **Conferences of the Parties (COP),** the first held in 1995 in Berlin, to assess progress in dealing with climate change. Beginning in the mid-1990s the focus has been to negotiate the Kyoto Protocol in order to establish legally binding obligations for developed and developing countries to reduce their greenhouse gas emissions.17 such meetings have been held. This year 2011, the COP will be held in South Africa and next year Qatar or South Korea. This underscores the seriousness of the drive to implement change.

There are many influential personalities in the world who also bring pressure to bear on governments, businesses and individuals. One such person is a Yale University economics professor William Nordhaus who argues that the price of carbon needs to be high enough to motivate the changes in behavior and changes in economic production systems necessary to effectively limit emissions of greenhouse gases.

Raising the price of carbon will achieve a number of goals;

1. First, it will provide signals to consumers about what goods and services are high-carbon ones and should therefore be used more sparingly.
2. Second, it will provide signals to producers about which inputs use more carbon (such as coal and oil) and which use less or none (such as natural gas or nuclear power), thereby inducing firms to substitute low-carbon inputs.
3. Third, it will give market incentives for inventors and innovators to develop and introduce low-carbon products and processes that can replace the current generation of technologies.

Remember each step towards a greener operation will improve air quality. One must not however lose sight of the fact that besides the recognized GHG's there are many other pollutants that need to be controlled inside and outside.

MOTTAINAI

Mottainai is a Japanese term meaning "a sense of regret concerning waste when the intrinsic value of an object or resource is not properly utilized"."

And so what does this have to do with us and what can we do about it?

If one was introspective, even for the groups that are already well advanced in the greening of their future, one would have to be honest and say that many of us still have a sense of "mottainai"

For the Explosives industry to get that competitive advantage and for us to get ahead of the game there are a number of areas that can be investigated to make effective change in order to make our operations greener.
They do not preclude the tried and trusted principles of the 3R's being reduce, re-use and recycle.

They do include another set of 3R’s for existing facilities, which could be known as Rethink, Revise and Restore/Retrofit and if one has the luxury for brand new facilities, Renewable, Rethink, Re-design.
These in turn include investigating amongst others:

- **Renewable energy and Energy efficiency**
- **Efficient use of resources such as water and power Water efficiency**
- **The use of environmentally friendly building materials**
- **Use of green raw materials**
    - **-Production**
    - **-Waste reduction**
    - **-Toxic substance reduction**
- **Air quality inside and outside**

There are countless tools available to aid the process of investigation and examples of these include:
Cost benefit analyses, ecological foot printing, environmental impact studies, life cycle analyses and assessments, input output analyses, material flow analyses etc.

QUESTION: HAVE YOU CONSIDERED ANY OF THESE DISCUSSED BELOW?

Renewable energy and Energy efficiency

Renewable energy includes non-fossil fuels such as wind and solar power, hydropower, biomass, geothermal and ocean energy.
It goes without saying that some of these would be more effective in some areas compared to others. How can these be used effectively on our sites?

- Solar and/or Wind power.  

Where these forms of generation are employed it may be useful to consider what is known as a “smart grid”. The “smart grid” includes an intelligent monitoring system that can integrate alternative sources of electricity, such as solar and hydropower with existing forms of power generation.
Generated solar and wind power could effectively be used to supply or supplement power to the general lighting of buildings and their surrounds, sign boards, emergency lighting battery packs, air conditioning etc.

- Hydropower  H_2O

Where there is a choice, this is the route to follow, as it precludes the obvious emission of GHG. Where large volumes of water are pumped along pipelines in-line generation systems have become practical and cost effective.

Most small-scale hydro systems require very little or no reservoir in order to power the turbines. These systems are commonly known as ‘run-of-river’, meaning the water will run straight through the generator and back into the stream. This has a minimal environmental impact on the ecosystem.
It only takes a small amount of flow (as little as 10litres per minute) or a drop as low as 0.5m to generate electricity with micro-hydro systems. Electricity can be delivered as far as 0.6km away to the location where it is being used.
If a site produces a large amount of excess energy, some power companies will buy back the electricity overflow and one also then has the ability to supplement the level of micro-power with intake from the power grid.
Technological advances (such as maintenance-free water intake equipment and solid-state electrical equipment) ensure that these systems are often more reliable in remote areas. Often these systems are more dependable and of better quality than the local grid particularly if state of the art electronic control equipment, invertors and alternators are used. The electricity generated can also be fed into the “smart grid”

❖ Biomass

Although there is probably little opportunity for the explosives industry to take full advantage of this form of energy generation, the generation of biomass wastes does present itself in many forms, including "wood waste" (such as shipping pallets and leftover construction wood), the biodegradable portion of garbage (paper, food, leather, yard waste, etc.) and the gas given off by landfills when waste decomposes. Biomass gas systems capture methane released from the plants and burn it in a gas turbine to produce electricity, the burning of waste explosives is one possible way of capturing this form of energy. It must also be borne in mind that when explosives are incinerated rather than just burnt in the open or burnt semi-confined they are by and large highly exothermic and therefore “store” huge amounts of energy.

Energy is also being generated from biomass, by the use of thermo chemical (controlled heating to gas), biochemical (using bacteria) and chemical processes.

These are other ways of generating energy but are probably not appropriate for our industry. Hydrogen & Fuel Cells

Energy efficiency. (**Efficient use of resources such as water and power)**

This is an area where our explosives industry can make a contribution.

When electricity is generated, the heat produced as a by-product can be captured and used for process steam, heating or other industrial purposes. Conventional electricity generation is about 30 % efficient, whereas combined heat and power (also called co-generation) converts up to 90% of the fuel into usable energy.

Advanced boilers and furnaces can operate at higher temperatures while burning less fuel. These technologies are more efficient and produce fewer pollutants.

Over 45 % of the fuel used by US manufacturers is burnt to make steam. The typical industrial facility can reduce this energy usage by 20% (according to the US Department of Energy) by insulating steam and condensate return lines, stopping steam leakage, and maintaining steam traps.

Electric motors run on a constant flow of energy, but an adjustable speed drive can vary the motor’s energy output to match the load. This achieves energy savings ranging from 3 to 60 %, depending on how the motor is used. Many industries use compressed air for instrumentation, sand blasting, painting, or other tools. According to the US Department of Energy, optimizing compressed air systems by installing variable speed drives, along with preventive maintenance to detect and fix air leaks, can improve energy efficiency by 20 to 50%.

New street lighting technologies, such as LED or induction lights, emit a white light that provides high levels of scotopic lumens allowing street lights with lower wattages and lower photopic lumens to replace existing street lights
Scotopic vision is the vision of the eye under low light conditions

In 2007, the Civil Twilight Collective in the US created a variant of the conventional LED streetlight, namely the Lunar-resonant streetlight. These lights increase or decrease the intensity of the streetlight according to the lunar light. This streetlight design thus reduces energy consumption as well as light pollution.

The use of environmentally friendly building materials

A building’s location and surroundings play a key role in regulating its temperature and illumination. For example, trees, landscaping, and hills can provide shade and block wind. In cooler climates, designing buildings with “sun”- facing windows increases the amount of sun (ultimately heat energy) entering the building, minimizing energy use, by maximizing passive solar heating. Effective building design, including energy-efficient windows, well-sealed doors, and additional thermal insulation of walls, basement slabs, and foundations can reduce heat loss by 25 to 50 %. Dark roofs may become up to 39 C° (70 F°) hotter than the most reflective white su rfaces and they transmit some of this additional heat inside the building. US Studies have shown that lightly colored roofs use 40 % less energy for cooling than buildings with darker roofs. White roof systems save more energy in sunnier climates. Advanced electronic heating and cooling systems can moderate energy consumption and improve the comfort of people in the building.

Proper placement of windows and skylights and use of architectural features that reflect light into a building can reduce the need for artificial lighting. Increased use of natural and task lighting have been shown by one study to increase productivity in schools and offices. Compact fluorescent lights use two-thirds less energy and may last 6 to 10 times longer than incandescent light bulbs Newer fluorescent lights produce a natural light, and in most applications they are cost effective, despite their higher initial cost, with payback periods as low as a few months.

Effective energy-efficient building design can include the use of low cost Passive Infra Reds (PIRs) to switch-off lighting when areas are unoccupied such as toilets, corridors or even office areas out-of-hours. In addition, lux levels can be monitored using daylight sensors linked to the building's lighting scheme to switch on/off or dim the lighting to pre-defined levels to take into account the natural light and thus reduce consumption. These can all be linked in one centralized computer to control the whole building's lighting and power requirements.

The choice of which space heating or cooling technology to use in buildings can have a significant impact on energy use and efficiency. For example, replacing an older 50% efficient natural gas furnace with a new 95% efficient one will dramatically reduce energy use, carbon emissions, and winter natural gas bills. Ground source heat pumps can be even more energy efficient and cost effective. These systems use pumps and compressors to move refrigerant fluid around a thermodynamic cycle in order to "pump" heat against its natural flow from hot to cold, for the purpose of transferring heat into a building from the large thermal reservoir contained within the nearby ground. The end result is that heat pumps typically use four times less electrical energy to deliver an equivalent amount of heat than a direct electrical heater does. Another advantage of a ground source heat pump is that it can be reversed in summertime and operate to cool the air by transferring heat from the building to the ground. The disadvantage of ground source heat pumps is their high initial capital cost, but this is typically recouped within 5 to 10 years as a result of lower energy use.

Smart meters are slowly being adopted by the commercial sector to highlight to staff and for internal monitoring purposes the building's energy usage in a dynamic presentable format.

Use of green raw materials

Below are given just a few of many examples of the efforts being made to green our explosives production and waste control.

Production

The use of green raw materials semi-products and products embraces many facets. One such facet involves the replacement of existing lead containing substances with materials that are more environmentally friendly.
Many of our operations for instance make the use of lead in the form of lead styphnate, azide, nitrate, ethyl hexolate, oxide, stearate, sulphate etc.
What can we do to reduce the amount of lead in our production systems? Below given are but a few of many examples of how scientists are working towards solving this problem.

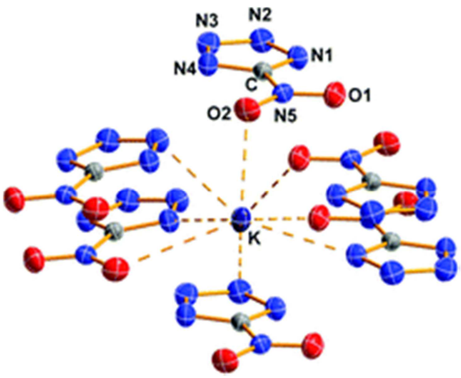
Thomas Klapötke and some of his colleagues at the Ludwig-Maximilian University of Munich have synthesized a family of alkali metal salts with the energetic **5-nitrotetrazolate anion** as a replacement for lead azide.

The salts with the harder lithium and sodium cations were found to contain crystal water, which gives them low sensitivity towards shock and friction. The rest of the alkali metal salts form as the anhydrous species, and show increased explosive sensitivities making them most useful as prospective replacements for commonly used primary explosives.

Klapötke says that the new primary explosives work well for military use. However more work is needed to improve their thermal stability for use in harsher conditions, such as for oil drilling. Joseph Backofen, BRIGS Co., Herndon, US, an expert in ballistics, comments 'this work represents a clear path towards developing new energetic materials that are free from constituents deemed harmful to their users during routine work.

Extract from "Klapötke" paper:
Alkali metal 5-nitrotetrazolate salts: prospective replacements for service lead(II) azide in explosive initiators
Thomas M., Carles Miró Sabaté and Jan M. Welch

A family of sensitive energetic salts of the 5-nitrotetrazolate anion with alkali metal cations (Li^+ 1, Na^+ 2, K^+ 3, Rb^+ 4 and Cs^+ 5) were synthesized either by the digestion of an acid copper salt of 5-nitrotetrazole with a suitable metal hydroxide, or alternatively by reaction of ammonium 5-nitrotetrazolate with a suitable metal base (MOH, $MHCO_3$ or M_2CO_3) in aqueous or alcoholic solution. All the compounds were characterized by analytical methods (elemental analysis and mass spectrometry) and spectroscopic methods (NMR and vibrational spectroscopy). The lighter metal salts **1** and **2** incorporate three and two crystal water molecules in the structure, respectively, whereas the heavier alkali metal derivatives form anhydrous species, and thus showed enhanced sensitivity to friction and shock. In addition, the crystal structure of each of the new materials was determined by X-ray diffraction techniques (1 and **3**: monoclinic, $P2_1/c$; **2**: triclinic, $P\bar{1}$; **4**: monoclinic, *Cc* and **5**: monoclinic, $C2/c$). The thermal stability of compounds **1–5** was assessed by differential scanning calorimetry (DSC) measurements showing significant thermal stability. Lastly, the energies of combustion of **1** and **2** were measured experimentally using oxygen bomb calorimetry (1, -1340(15) cal g^{-1} and **2**, -1200(20) cal g^{-1}) and was used to calculate their standard molar heats of formation (**1**, -610(55) kJ mol^{-1} and **2**, -360(65) kJ mol^{-1}).



Another interesting paper to read is: Green primaries: Environmentally friendly energetic complexes
My Hang V. Huynh, Michael A. Hiskey, Thomas J. Meyer, and Modi Wetzler
Where they" report on report four previously undescribed green primary explosives based on complex metal di-anions and environmentally benign cations, $(cat)_2[M^{II}(NT)_4(H_2O)_2]$ (where cat is NH_4^+ or Na^+, M is Fe^{2+} or Cu^{2+}, and NT^- is 5-nitrotetrazolato-N^2)."

Primary explosives are used in small quantities to generate a detonation wave when subjected to a flame, heat, impact, electric spark, or friction. Detonation of the primary explosive initiates the secondary booster or main-charge explosive or propellant. Longterm use of lead azide and lead styphnate as primary explosives has resulted in lead contamination at artillery and firing ranges and become a major health hazard and environmental problem for both military and civilian personnel. Devices using lead primary explosives are manufactured by the tens of millions every year in the United States from primers for bullets to detonators for mining. Although substantial synthetic efforts have long been focused on the search for greener primary explosives, this unresolved problem has become a "holy grail" of energetic materials research. Existing candidates suffer from instability or excessive sensitivity, or they possess toxic metals or perchlorate. We report here four previously undescribed green primary explosives based on complex metal dianions and environmentally benign cations, $(cat)_{2}[M^{11}(NT)_{4}(H_{2}O)_{2}]$ (where cat is NH_4^+ or Na^+, M is Fe^{2+} or Cu^{2+}, and NT^- is 5-nitrotetrazolato-N^2). They are safer to prepare, handle, and transport than lead compounds, have comparable initiation efficiencies to lead azide, and offer rapid reliable detonation comparable with lead styphnate. Remarkably, they possess all current requirements for green primary explosives and are suitable to replace lead primary explosives in detonators. More importantly, they can be synthesized more safely; do not pose health risks to personnel, and cause much less pollution to the environment.

The development of **non-primary explosives detonators (NPED's**) has had a lot of focus. There are a number of these devices under patent. The thrust here is to get rid of the primary explosives in the detonator.

A team of scientists from the Georgia Tech Research Institute (GTRI) and the Indian Head Division of the Naval Surface Warfare Center have developed highly-uniform copper structures that will be able to be incorporated into integrated circuits and then be chemically converted to millimeter-diameter explosives. Because they can be integrated into standard microelectronics fabrication processes, the copper materials will enable micro-electromechanical (MEMS) fuses for military munitions to be mass-produced like computer chips

Diazodinitrophenol (**DDNP)** is used with other materials to form priming mixtures, particularly where a high sensitivity to flame or heat is desired. DDNP is often used as an initiating explosive in propellant primer devices and is a substitute for lead styphnate in what are termed "non-toxic" (lead free) priming explosive compositions.
It is less sensitive to impact but more powerful than mercury fulminate and lead azide. The sensitivity of DDNP to friction is much less than that of mercury fulminate, but it is approximately the same as that of lead azide.
DDNP may be desensitized by immersing it in water, as it does not react in water at normal temperature. A solution of cold sodium hydroxide can be used to destroy it.

Researchers from the Lawrence Livermore National Laboratory added ***environmentally friendly solvents*** to tri-amino-tri-nitrobenzene (TATB), as part of a project supported by the Transformational Material Initiative Laboratory Research and Development initiative. The result was improved crystal quality and chemical purity of the explosive. According to Larry Fried, the project's principle investigator, improved crystal quality and purity, leads to safer explosive material, because the material is less likely to react violently to heat or impact.

To achieve their results, the team used "**green" ionic liquids** in place of a class of chemicals called molecular crystals. Used as building blocks for a variety of applications, molecular crystals cannot be dissolved in common organic liquids, which means they form poor-quality crystals of limited size. The ionic liquids, however, are extremely effective in dissolving hydrogen-bonded materials, and produced defect-free crystals that were more than 97 percent TATB.

Toxic substance reduction and Waste reduction and treatment

Above were some examples of greener raw materials and products. It goes without saying that this leads to easier to handle waste i.e. the waste products do not contain unnecessary “nasties”.

Besides the tried and tested methods of waste reduction involving the three “R’s” the reduction of waste also embraces many other facets. Some of these relate to the “cradle to grave” principle. Below are more examples/ways in which toxic substances can be reduced in the environment.

Example 1

Extract from an article by Kurt kleiner *08 May 1999: Magazine issue 2185.*

Tobacco defuses an explosive situation

Some plants and bacteria already break down explosives that contain nitrogen and then use the nitrogen as a nutrient. But they cannot tolerate high levels of the toxic explosives, and don't convert them very quickly. Colonies of some bacteria are more efficient, but the process can be hard to replicate on a site unless the soil is dug up first, which is expensive.

So Christopher French of the University of Cambridge and his colleagues have engineered tobacco plants to express an enzyme from Enterobacter cloacae PB2, a micro-organism that breaks down explosives (Nature Biotechnology, vol 17, p 491). The tobacco plants that expressed the enzyme, pentaerythritol tetranitrate (PETN) reductase, could tolerate levels of TNT and nitroglycerine twice as high as could non-engineered plants, and converted the explosives into harmless compounds.

Example 2

A novel environmentally friendly 2,4,6-trinitrotoluene-based explosive

Gibson S. Nyanhongo[1], Nina Aichernig[1], Marcus Ortner[1], Walter Steiner[2], Georg M. Guebitz[1]
[1]*Department of Environmental Biotechnology, Graz University of Technology, Petersgasse 12, A-8010, Graz, Austria*
[2]*Institute of Biotechnology and Bioprocess Engineering,, Graz University of Technology,*
Petersgasse 12, A-8010, Graz, Austria.

A novel bioremediation technology was developed that involved the incorporation of a newly isolated *Pseudomonas putida* GG04 and *Bacillus* sp. SF into explosive formulations to enhance biodegradation of TNT residues and other explosives which fail to detonate due to technical problems. The incorporation of these microorganisms into the explosive did not affect the quality of the explosive in terms of detonation velocity while complete degradation of TNT moieties upon transfer in liquid media was observed after 4 days. The incorporated microorganisms sequentially reduced TNT leading to the formation of hydroxyl amino-dinitrotoluenes (HADNT), 4-amino-2,6-dinitrotoluenes; 2-amino-4,6-dinitrotoluenes; 2,6-diaminonitrotoluenes and, different azoxy compounds.

Example 3

Biodegradation of Nitro-Substituted Explosives 2,4,6-Trinitrotoluene, Hexahydro-1,3,5-Trinitro-1,3,5-Triazine, and Octahydro-1,3,5,7-Tetranitro-1,3,5-Tetrazocine by a Phytosymbiotic *Methylobacterium* sp. Associated with Poplar Tissues (*Populus deltoides* x *nigra* DN34)

Benoit Van Aken,* Jong Moon Yoon, and Jerald L. Schnoor
Department of Civil and Environmental Engineering, The University of Iowa, Iowa City, Iowa 52242

Scientists at the University of York have uncovered the structure of an unusual enzyme which can be used to reverse the contamination of land by explosives.

The discovery, by scientists in the York Structural Biology Laboratory and the Centre for Novel Agricultural Products, will support the development of plants that can help tackle pollution caused by royal demolition explosive, also known as RDX.

Researchers at York have identified bacteria that use RDX as a food source and used that knowledge to develop transgenic plants that can draw pollutants out of the soil and break them down.

OTHER AREAS OF WASTE REDUCTION

The challenge of e-waste

According to the 2010 National Waste Report, a relatively small country such as Australia generates more than 100,000 tonnes per year of e-waste in the form of old television sets and computers. This is expected to increase 80% by 2027-28.

Most of these end up in landfill, with some small amounts being recycled.

While Australia has banned the import of certain POPs, industrial chemical laws do not prevent the importation of the chemicals in consumer products. This holds true for many other countries.

Packaging

How much thought goes into your packaging? Has a life cycle assessment been carried out? Has the impact on the environment been considered? Has the cradle to grave cycle been closed out effectively? Has your industry considered using bio-plastics for your packaging?
Examples of some of these are;

Starch based plastics

Constituting about 50 percent of the bio-plastics market, thermoplastic starch, such as Plastarch Material, currently represents the most important and widely used bioplastic. Pure starch possesses the characteristic of being able to absorb humidity, and is thus being used for the production of drug capsules in the pharmaceutical sector. Flexibiliser and plasticizer such as sorbitol and glycerin are added so the starch can also be processed thermo-plastically. By varying the amounts of these additives, the characteristic of the material can be tailored to specific needs (also called "thermo-plastical starch.

Polylactic acid

Polylactic acid (PLA) is a transparent plastic produced from cane sugar or glucose. It not only resembles conventional petrochemical mass plastics (like PE or PP) in its characteristics, but it can also be processed easily on standard equipment that already exists for the production of conventional plastics. PLA and PLA blends generally come in the form of granulates with various properties, and are used in the plastic processing industry for the production of foil, moulds, tins, cups, bottles and other packaging.

Poly-3-hydroxybutyrate (PHB)

The biopolymer poly-3-hydroxybutyrate (PHB) is a polyester produced by certain bacteria processing glucose or starch. Its characteristics are similar to those of the petro-plastic polypropylene. The South American sugar industry, for example, has decided to expand PHB production to an industrial scale. PHB is distinguished primarily by its physical characteristics. It produces transparent film at a melting point higher than 130 degrees Celsius, and is biodegradable without residue.

Bio-derived polyethylene

The basic building block (monomer) of polyethylene is ethylene. This is just one small chemical step from ethanol, which can be produced by fermentation of agricultural feed stocks such as sugar cane or corn. Bio-derived polyethylene is chemically and physically identical to traditional polyethylene - it does not biodegrade but can be recycled. It can also considerably reduce greenhouse gas emissions. Brazilian chemicals group Braskem claims that using its route from sugar cane ethanol to produce one tonne of polyethylene captures (removes from the environment) 2.5 tonnes of carbon dioxide while the traditional petrochemical route results in emissions of close to 3.5 tonnes.
Genetic modification (GM) is also a challenge for the bioplastics industry. None of the currently available bioplastics - which can be considered first generation products - require the use of GM crops.

Looking further ahead, some of the second generation bioplastics manufacturing technologies under development employ the "plant factory" model, using genetically modified crops or genetically modified bacteria to optimize efficiency.

WHAT CONTRIBUTION ARE YOU/WE MAKING?