What is biodegradation?
Biodegradation is the process by which organic substances are broken down by living organisms (96% of Bacteria are aerobic - active in the presence of oxygen). There is therefore complete compatibility between the Bacterial floral and Oxobiodegradable degradation pathways. The term is often used in relation to ecology, waste management, environmental remediation (bioremediation) and to plastic materials, due to their long life span. The use of oxo-biodegradable additives significantly accelerate this streak down/disintergration process in conventional packaging plastics.

What are the different types of degradable plastics?
There are mainly two types - oxo-biodegradable (oxygen) and hydro-biodegradable (moisture), sometimes called starch based. Both degradable solutions use oxygen to degrade (although Hydrobiodegradable will degrade anoxically also - producing Methane). The starch based products tend to degrade slightly faster but these materials are known not to be as strong as oxo-biodegradable ones (e.g. in bag form structuraly they are too weak to carry liquor bottles). They meet the international compostable plastic standards that were spesifically designed for them (ASTM D6400/EN 13432). Hydro-biodegradable products are designed to enter an industrial composting system. Only hydro-biodegradable products cannot be recycled. They should not enter the existing recycling stream as they have a totally different chemical structure that of conventional plastics.

What is oxo-biodegradation?
The oxo-biodegradation process uses two methods to start the biodegradation. These methods are photodegradation (UV) and thermal oxidation. The UV degradation uses UV light to fragment and degrade the product. The thermal oxidation process uses time, and heat to break down the plastic. Both methods rapidly reduce the molecular weight of the plastic and allow these fragments to biodegrade much faster than they naturally would without the inclusion of an degradation accelerator.

What is the chemical mechanism of oxobiodegradation?
The chemical mechanism of oxobiodegradation is a oxygen radical chain splitting that degrades the long chain polymers and at the same time 'oxygenates' them with hydroxy and carboxy groups to make the small (MW 1.000-5.000 amu) molecules hydrophilic and bioavailable. The oxobiodegradable additives catalyse the natural process to make the polymer degrade with a designed life time.

This article by Sipinen and Rutherford (published in Journal of Environmental Polymer Degradation in 1993) describes the metals that have been used, their mechanism and rates of degradation in a thorough manner.

How is oxo-biodegradation different from biodegradable?
Oxo-biodegradable plastics degrade as a result of physical and chemical oxidation impact, the moleclue in chains are fractured into smaller and smaller pieces and after a certain point **biodegradation** takes over and alll that will remain is H2O, CO2 and biomass. Biodegradable plastics degrade as a result of aerobic and anaerobic bacterial activity. Unlike conventional plastics and oxo-biodegradable plastics, bio-polymer plastics are made by starch (usually corn or sugar) - PLA materials.

Definitions of the types on degradable plastics:
oxo-bidegradable plastic - a plastic designed to undergo a significant change in its chemical structure under specific environmental conditions resulting in a loss of properties and thereupon actions of micro-organisms completes the degradation/biodegradation (as described in ASTM D 6954-04).

biodegradable plastic - a degradable plastic in which the degradation results from the action of naturally occurring micro-organisms such as bacteria, fungi and algae.

Are all degradable products the same?
No. There are two broad categories - oxo-biodegradable and hydro-biodegradable, sometimes called starch based. These starch based products tend to degrade slightly faster but are known not to be as strong as industrial oxo-biodegradable ones (e.g. they are too weak to carry liquor bottles). They meet the international compostable plastic standards that were designed for them. Hydro-biodegradable products can not be commingled in the existing recycle stream as they have a totally different chemical structure than conventional plastics. Both have possible market niches where they have potential advantages.

Can degradable products be recycled?
Yes. Oxo-biodegradable end products containing Renatura™ may enter the recycling stream. Industrial scale testing up to 80 % added Renatura™ containing plastics shows that there is no effect on the process or the product and no "follow-on" effect. In some cases the recycled granulate might be improved from improved blending. Some photodegradable products containing other degradable additives should not be recycled. Hydro-biodegradable end products can not be recycled, they will "contaminate" to

recycling process and the resultant recycling material as they have a totally different chemical structure than conventional plastics.

How is Renatura™ used?
Renatura™ is delivered as masterbatch granulate and is usually included into the polymer mix in the production stage usually at the 2 % rate (by weight).

Where can Renatura™ be used?
Renatura™ can be used in all types of PP and PE based plastic products.

Where can we purchase Renatura™?
To purchase Renatura™ contact one of our distributors located in your region (under "Products" - "Distributors"). If you are a supplier to the polyolefin plastic/associated industry please contact us at mail@nor-x.no.

Are there any production/manufacturing realted concerns with Renatura™ in production?
No. Renatura™ is added as a granulate masterbatch and require no changes in production.
There are no major alternations adjustments required to the extrusion/production equipment.

Can Renatura™ be used in e.g. food packaging?
Yes. Renatura™ is food contact, no migration status, approved.

How is shelf life of Renatura™ products?
With the addition of the Renatura™ additive, there are no difficulties with regards to the shelf life of the degradable product.
The degradation of products containing Renatura™ starts when the product is exposed to sunlight and/or heat. Therefore can these products be stored for a longer period of time

without loosing any its properties. The shelf life of plastics can be designed to suit the distribution channel and use of degradable product(s)

What is left after the degradation process?
All that is left of a product containing Renatura™ after complete degradation, is H2O, CO2 and biomass. After Phase I (the physico-chemical degradation) short low molecular weight compounds (< MW 5.000) remain - these are subsequently biodegraded by Fungi, Bacteria and Algae to CO2, H2O and new biomass (see the Environmental Claim Statement)

Is there any known potential risk to nature?
No. Renatura™ does not contain any toxic "heavy" metals and has a environmental claim statement proving that it does not harm nature.

How do Renatura™ products meet international standards for degradable plastics?
The only standards that currently exist are for 'compostable plastics' (hydro-biodegradable) and these are not designed for oxo-biodegradable products.

Oxobiodegradable products meet three of the four criteria in the above standards - they meet the particle size, mineralisation and compost compatibility (as pr. ASTM D6954-4), but they do not 'compost' **fast enough**. The 2002 Quebec study found that they will compost well and will make high quality compost. In order to avoid confusion in the marketplace they are not advertised as being compostable. The Oxo-biodegradable Plastic Institute (OPI), the international industry association, is working with the BNQ and others in order to develop a Quebec program to certify compostable plastic bags. A standard for the behaviour of the plastics in land fill is in development at ASTM and a standard guide (provides methods but not pass/fail criteria), ASTM D6954-2004, that recognizes oxo-biodegradability as a viable process, exists.