Synthetic fibers stem from expertise in polymers manufacturing. Polymers chemistry and the possibility to adjust their formulas give fibers all desired features and colours. The image portrays chemical intermediates and natural coloured and additivated polymer granules

Polyamide

by **Aurora Magni**

RadiciGroup and the future of synthetic fibres

A long time has passed since Nylon Day was celebrated on 15th of May 1940, when polyamide – the name of the fibre of which nylon is the commercial brand – officially entered the markets through nylon tights, a revolution that had a huge impact on fashion and the habits of millions of consumers. Polyamide is a fossil-derived fibre – currently its raw materials are oil derivatives produced by the petrochemical industry – and together with polyester it is among the most widely used fibres in the textile industry, with a variety of uses, from fashion to textiles for technical applications.

Polyamide's success, as well as for the other synthetic fibres, is dependent on two factors. The first one is its functional performance: great versatility and resistance which makes it suitable to many applications, from underwear to sports clothing, from casual fashion to the production of textiles for furnishing and car interiors, from carpets to technical textiles (for example work uniforms, fishing nets, filtrations and other industrial applications).

The second one is the limited availability of natural fibres – the availability of land where to grow them is limited and in competition with production of food. The growing demand for fibres in the fashion industry in the last decades has therefore been partly met by synthetic fibres.

Dependence on fossils and non renewable materials – releasing CO_2 emissions in the atmosphere and with long-term availability issues – and productive processes with a high-energy load which use chemical substances – some of which are potentially dangerous for the environment and human health – make polyamide and synthetic fibres in general the best materials in the search for innovative technological solutions that could increase their sustainability. Polyamide has revolutionized and improved the way we dress, and going back to a world where we only dress in natural fibres is unthinkable and perhaps even less sustainable.

History

RadiciGroup was founded by Pietro Radici, who, in the dark days of Fascism, used to travel through Italy with a carriage full of blankets, setting the foundations for a story of entrepreneurial success. The first productive plant was opened in 1941 in Val Gandino. It was called Tessiture Pietro Radici Spa. Initially it produced blankets and bed covers, promoting that wool from Bergamo which, although lacking the softness of noble fibres, satisfied the needs of its customers in the war period. In the 1950s, the first transformation took place. The company, then run by his son Gianni, started producing carpets, textiles and car mats. Without being aware of it, Radici was among the pioneers who inaugurated a market of technical textiles, which would then change the very way textiles and yarns are thought of, and would value their performance depending on their different applications.

The economic boom and the growth of the chemical industry stimulated further productive diversification, and Radici made its way into the chemical sector through the production of polymers and synthetic fibres.

In the 1980s, its chemical vocation was already a daily practice. With the acquisition of a former Montedison productive site in Novara, Radici

1 The energy mix of the RadiciGroup companies allowed for the achievement of interesting results. In 2015 the percentage of electric energy from renewable sources used by the company amounted to 48.5% (+3% compared to 2014), with seven productive sites 100% operated by renewable energy. In the three-year period 2013-2015 the total consumption of primary energy from fossil sources per ton of product decreased by about 14.3%

Chimica Spa was founded, with the aim of developing the technopolymers' market and creating new production technologies.

In the 1990s, the company was ready for new productive integrations. It invested in cogeneration and hydroelectric energy production, and through the creation of Radici Energie, the company became autonomous and entered the energy market providing an integrated system of products, services and consultancies to external companies.[1]

In most recent times, in addition to the globalization of productive activities, there has been an increase in research and innovation activities in relation to both products and their transformation processes. This is all explained in the sustainability reports, a tool that the company adopted in 2004 to make its work, its achievements and its future plans public. The first report already mentioned what would then become a mission for the company: "To be glocal: global thinking, local action", the slogan that aptly summarizes the vision of a company determined to produce and sell all over the world without forgetting its own origins and culture.

Looking at the world from the Bergamo valleys

RadiciGroup – which currently employs about 3,000 people in 33 sites ranging from commercial offices to productive unities in 16 countries, with a yearly turnover of over a billion euros – still operates as a family company. It is led by Angelo, Maurizio and Paolo Radici, with an organizational model oriented towards managerialism and the participation of executives and technical staff in strategic decisions.

The strategies, the ideas, the most advanced experimentations take

place in the mountains near Bergamo and in the plain around Novara. It is a complex system organized by Radici Partecipazioni Spa, which includes the different geographical unities as well as the three productive areas: Specially Chemicals, Performance Plastics and Synthetic Fibres & Nonwovens.

With a 412 million euro turnover in 2016 (about 45% of total turnover) the supply chain of man-made fibres and nonwovens represents the core business of the company, which this way is rediscovering its textile vocation.

It is in this context that the production of synthetic yarns, and in particular polyamide, takes place. The first investments for the plants of polymerization of Polyamide 6 (PA6) date back to the 1960s and in the following years the vertical integration (polymers and synthetic fibres) was introduced, soon followed by polymerization and polyester spinning. Finally, in the 1980s, the polymerization of PA6.6 took place, and recently polyamide from renewable sources was achieved.

The synergic and vertical integration, in particular in the polyamide chain, represents a point of strength of the group, which this way has total control of its productive chain, from the chemical intermediates to the production of yarns, plastic technopolymers and the TNT. This is a condition which plays an important role in the definition of fibres in terms of sustainability.

Distaffs, bobbins and beams having different features, shapes and colours, yarn ready to be woven, knitted and tufted

Process, product and system controls. Technology and human beings collaborating for quality

Reducing the environmental impact of man-made fibres is possible

Consumers have long appreciated the comfort, the resistance, the performance and the practicality of synthetic fibre clothing (for example the low workload necessary for their maintenance: they are cold-washed and do not need ironing). Although it is still widely believed that cotton is healthier for the skin, the use of man-made fibres in sporting and protective clothing, as well as in fashion, is an unstoppable trend. Statistics document a constant growth in consumption of chemical fibres worldwide: in 2014 over 60 million tons of polymers and synthetic yarns were produced (source: CIRFS). This is mainly the result of their use in contexts such as cars, industry, furniture, the building sector and agriculture, different from the clothing sector and capable of absorbing high volumes of raw materials. RadiciGroup is part of this trend with it annual production of 90,000 tons of polyamide and 24,000 tons of polyester.

However, to balance the technical performances of this fibre, there are some critical environmental points, ranging from its fossil fuel origin to the environmental cost of its manufacturing (energy consumption and emissions). At its end of life, the lack of biodegradability of the product, which requires hundreds of years to be metabolized by the environment, is perhaps the most serious problem.

The first point represents an intrinsic characteristic of synthetic fibres, a critical point that can be improved only introducing raw material from recycling of post-production residues and/or post-consumption products. The lack of biodegradability of the materials not only pushes towards incentivizing recycling processes as a systematic practice, but has also led producers towards an intensification of research, inserting in the polymer formation raw materials from renewable sources. This solution however does not convince some experts: as in the case of biofuels, the cultivation of crops to be destined to these processes can subtract soil and water from the production of food.

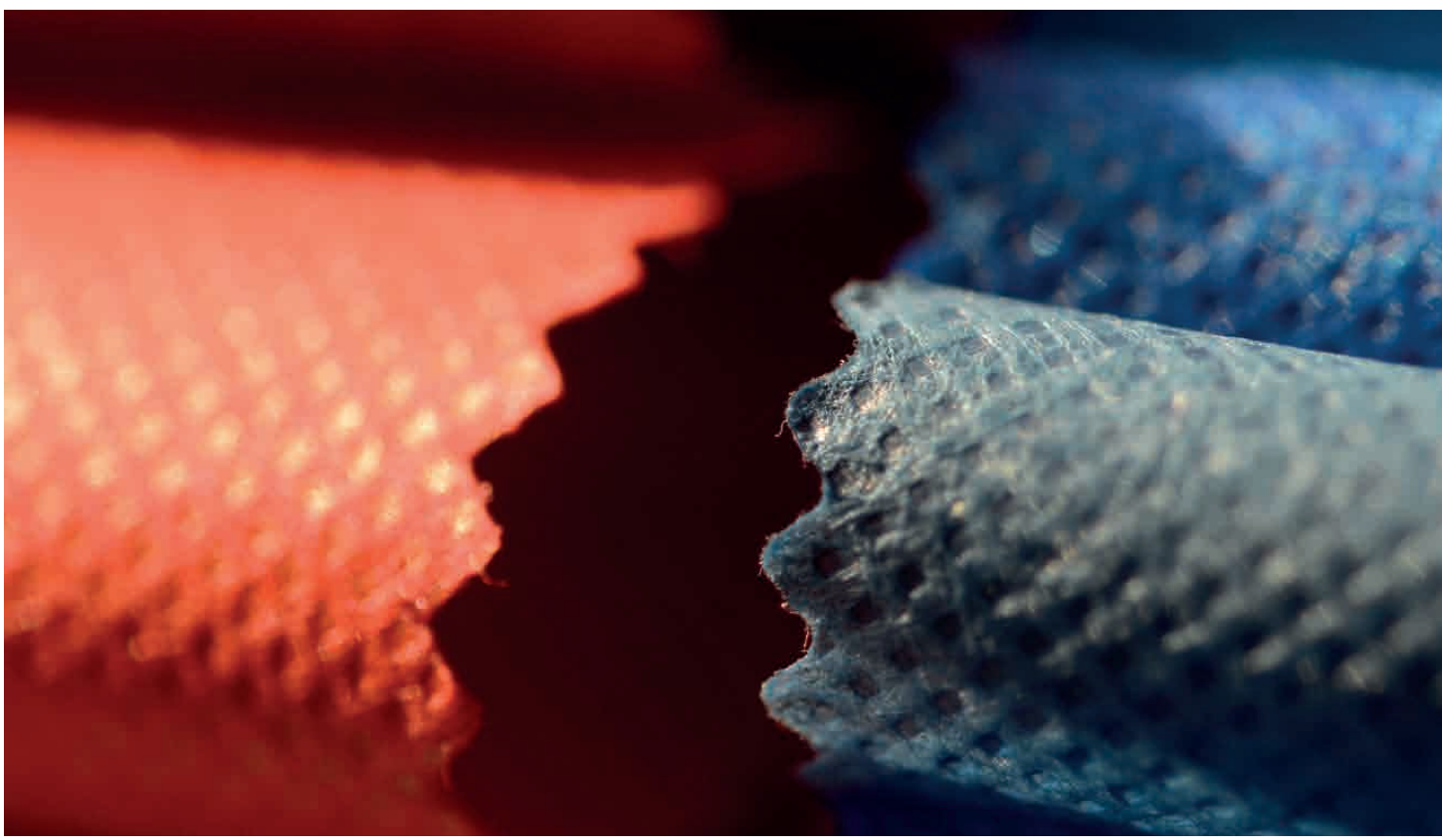
Aware of these problems, RadiciGroup has concentrated its efforts on four objectives:

- production of lines of polyamides from recycling destined for thermoplastic uses;
- production of lines of polyester fibre from recycling;
- creation of biopolymers from renewable resources that do not compete with food production;
- production of polyamides and polyesters from processes with increasingly reduced environmental impacts.

It is necessary to specify that in the group's strategy the R&S activities for green production are strongly connected to technological investments and the adoption of scientific methodologies capable of measuring the environmental performances of the different productive steps and their outputs. The choice of submitting 90% of their key products to LCA (Life Cycle Assessment)[2] and to subsequent improvements in the methodology such as PEF[3] is therefore understandable. This is a policy that commits RadiciGroup to a rigorous quantification

2 A tool used to evaluate the life cycle of a product, preventively identifying the boundaries of the analysis with the aim of measuring its environmental impact. The LCA implementation modalities are indicated in the Iso 14040 norms

3 PEF (Product Environmental Footprint) refers to the 2013 /179/EU recommendation by the European Commission of 9th April 2013. Although based on the LCA methodology, it aims to compare the environmental performances of products belonging to the same product category. It has been tested on 300 companies in the period 2013-2016 and has involved 25 typologies of products



of the impacts of processes and products through internationally acknowledged measuring instruments.

LCA's function is to identify critical environmental issues according to parameters of energy consumption and emissions along the life cycle of a product during pre-determined manufacturing phases. The results obtained allow the company to adopt correct measures, measuring the efficacy and comparing the ecological performances of a product before and after the investments or between competing products. They are at the base of EPD, the product environmental certification.[4]

By submitting the standard polyester and the one obtained from the recycling of PET to LCA, it has been possible to demonstrate that the use of second life raw material reduces the company's carbon emissions: for each kilogram of recycled PET up to three kilograms of carbon dioxide are saved. The data on energy savings also show a reduction for kg/product of energy consumption equivalent to 45-50% compared to the standard products. The data obtained also confirmed the company's choice of prioritizing mechanical recycling over the chemical one, which requires higher energy and water consumption, in addition

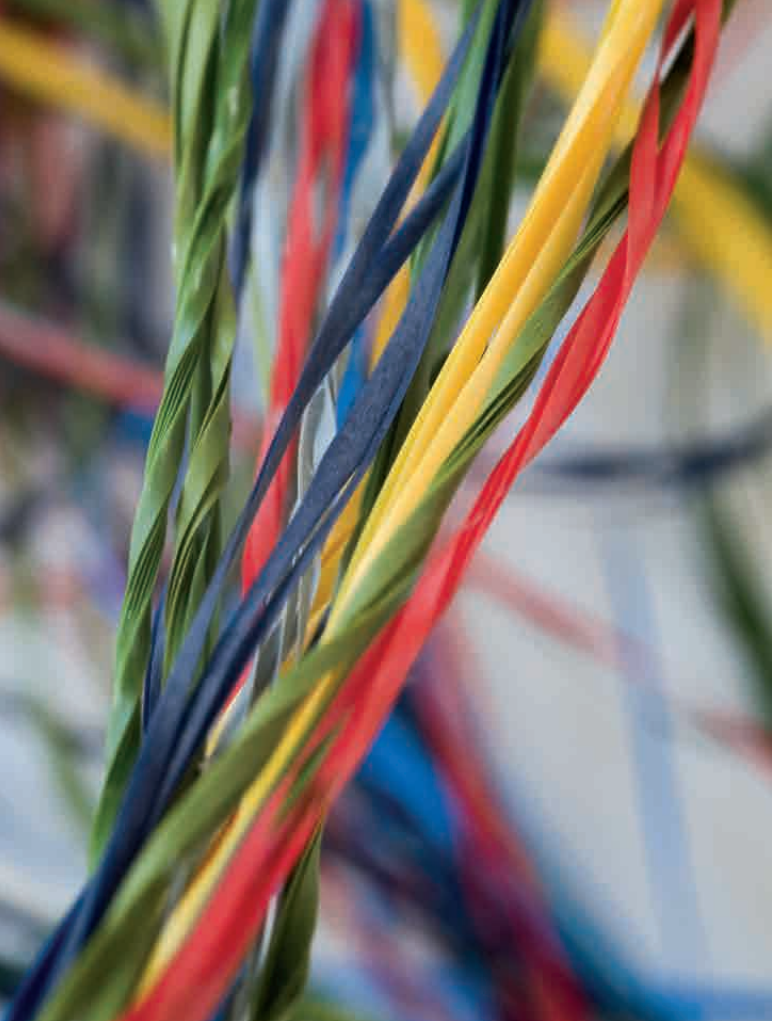
4 EPD, as set in communitarian environmental policies and deriving from the ISO 14020 norms, is a type III label, a document that lists objective, comparable and credibile information in relation to the environmental performance of products and services (source: ISPRA)

to the use of solvents and acids. A further innovation in the dyeing process of the recycled polyester by RadiciGroup has increased its environmental value. By dyeing the polymer en masse before the spinning phase, a significant saving in processed water (-90% compared to the yarn dyeing) was achieved. This positively impacts on energy consumption, which was reduced by about 60% compared to the yarn dyeing, as the heating of the dye bath was no longer necessary.

To increase the recyclability of synthetic materials, the company has chosen the route of Eco Design, designing materials also according to their post-consumption end of life. This approach has been implemented with the participation of universities like the Politecnico di Milano School of Design – Product design for innovation.

As far as RadiciGroup polymers from renewable sources are concerned, Cornleaf deserves a mention: a biosynthetic yarn from PLA (polylactic acid from corn), dyed en masse and with a bacteriostatic effect, and fully biodegradable. It is particularly suitable for clothing and underwear, and has been certified according to its antibacterial performances (norm ISO ENI UNI 20743:2007).

The production of polyamide also envisages a renewable version. RadiciGroup has developed polyamide 6.10 using a polymer 64% derived from sebacic acid which comes from the seeds of castor oil plant, whose cultivation, particularly common in India and China, takes place on semiarid terrains and therefore is not in competition with food crops. An ambitious project involves the production of a series of technopolymers according to the logic of circular economy. The Heramid are produced out of the industrial residues coming from the group's polymerization, spinning, staple and compound plants. Both the manufacturing processes and the phases of transfer and logistics have undergone an LCA with results that confirm the environmental value of recycling materials. The



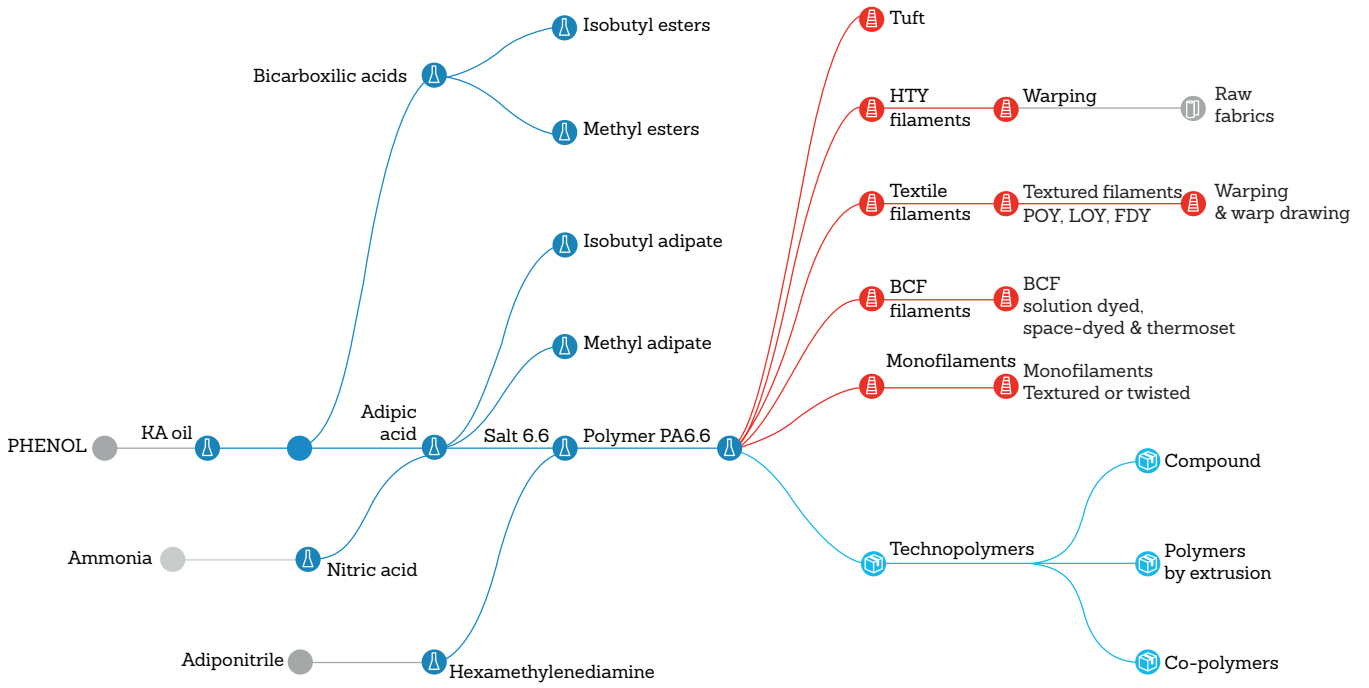
total control that a highly integrated company like RadiciGroup can operate on the whole of the polymer production chain down to the production of synthetic fibres, filaments and nonwovens, is the optimal condition to improve the ecological performances of man-made fibres.

The traceability and the monitoring of the processes have allowed the company to complete the PRC (Product Category Rules) on the whole of the supply chain, from the chemical part to the fibres and to their recycling. Validated by the International EPD System, they currently represent a model for any operator in the sector, who is interested in measuring the environmental performances of the products of that supply chain.

Poliammide 6 and 6.6 Radilon®, the continuous filament BCF[5] Radifloor® (PA6 e PA6.6) and the technopolymer of polyamide 6 and 66 recycled Heramid® have so far been granted EPD certification.

In addition to having constantly invested in research programmes aimed at reducing the environmental cost of manufacturing in terms of emissions and consumption, the company has chosen to document its own strategy in an objective way. This policy has started with the company's quality system: all the production plants have had at least a certified system, while over 90% of production sites operate according to the ISO 9001:2008 norms. Finally, it needs to be stressed that 12 companies out of 22 are in pos-

The RadiciGroup process with the highest vertical integration in the supply chain of polyamide 6.6



session of ISO 14001. As far as the chemical safety of the RadiciGroup man-mad filaments products is concerned, they are Oeko-Tex 100 certified, while for the polyester products derived from PET recycling, the company has chosen the certification awarded by Certiquality according to the norm UNI 11505:2013,[6] which confirms the second life origin of the raw material.

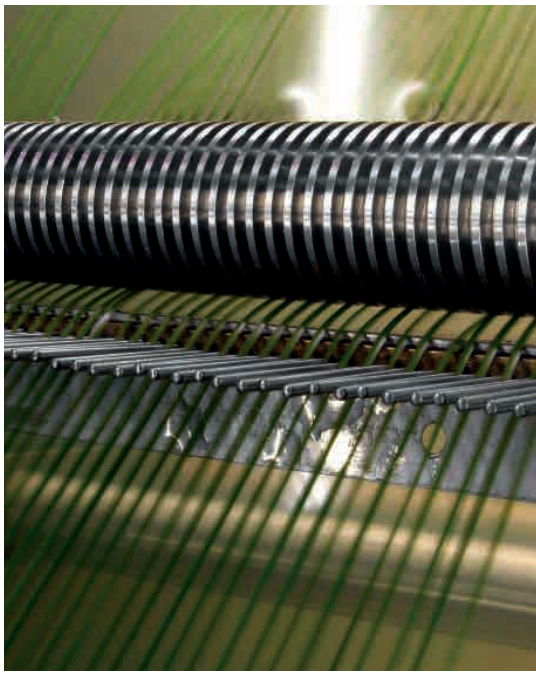
The effects of RadiciGroup's sustainability on fashion and consumption

Man-made fibres represent almost 70% of textile raw materials and their degree of sustainability can contribute to determine the ecological performances of consumption goods. Second life polyesters and bio-polymers increase the green content of the fashion item that contains them. These data find confirmation in a project realized in 2015-2016 by RadiciGroup with Eurojersey and the brand Herno, which allowed for a mapping of the environmental impact of a manly jacket in all the phases of its productive process from raw materials to production (polymerization, spinning, weaving and packaging). The project, carried out using the PEF methodology, allowed the final consumer to be aware of the item's environmental performances and to identify its environmental value as a chain value in accordance with law 221 of 28th December 2015, which promotes the circular economy. According to the PEF analysis, the production of the Herno item generated 90% less CO_2 emissions compared to the same item produced outside Europe. This value can also be translated in sustainability: the same jacket produced outside Europe generated an environmental cost equivalent to 5,22 euros, and only equivalent to 1,97 euros if produced in Italy. In other words, an item produced in other parts of the world costs less in productive terms, but has a significantly higher cost for the environment: +165%.

Another recent initiative showed how the components up the supply chain can positively interact with the downstream phases, not only with the packaging of items but also with their management and maintenance. The phenomenon, now widely documented, of the microplastic discharged by domestic and industrial washing of textile items in marine waters, has led the company to participate in a project realized in the framework of the EU programme Life+ by international partners including CNR-ISMAC from Biella. Tests on fabric samples carried out on continuous filaments of RadiciGroup polyamide and polyester showed a series of factors that influence the discharge of microplastic fibres during the washing processes: the intensity of the maintenance treatments, the type of detergent used, the characteristics of the fibre and the textile substratum such as the compactness and the tendency to pilling. On the basis of these indications, the partnership is now working on designing textile materials that are more resistant to the washing phases and that release fewer microplastics into the environment.

5 BCF stands for Bulked Continous Filament, produced through a system which curls the filament making it particularly suitable for the production of carpets

6 The polyester products r-Starlight®, r-Radyarn® are awarded this certification



RadiciGroup

2015 Turnover: €1,011 millions

Staff: 3,000

Position in the supply chain:

chemical/plastics/man-made fibres/TNT

HQ: Gandino (Bg)

Founded: 1941

Market: global

Main Materials Used: chemicals