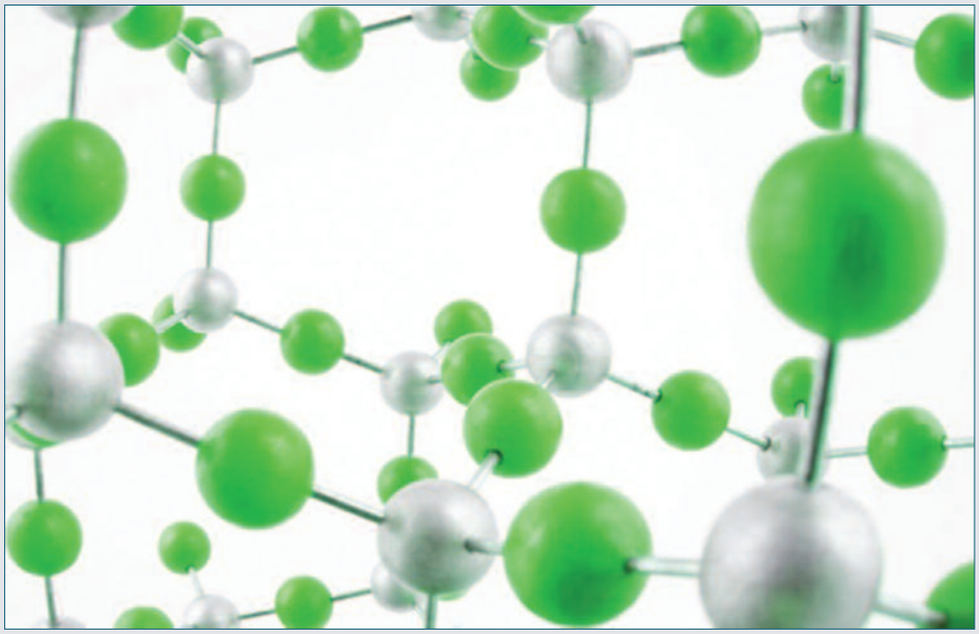

by Gabriele Centi, Siglinda Perathoner
Dipartimento di Chimica Industriale
ed Ingegneria dei Materiali
Università di Messina
and INSTM/CASPE
gabriele.centi@unime.it

IS THERE A STRATEGY FOR SUSTAINABLE (GREEN) CHEMISTRY IN ITALY?

Introduction

Polimeri Europa SpA has changed its name in April 2012 to Versalis (foreign subsidiaries will maintain their existing corporate names), and started at the same time a change of industrial strategy with a clear shift towards biomaterials and "green chemistry", even if it is a common practice in Europe (particularly, by large companies such as Basf, Bayer, Solvay, DSM, etc. as well as the European Federation of Chemical Industries - Cefic) to prefer the indication "sustainable" chemistry, being the concept of "green" chemistry too limited and somewhat controversial [1]. From June 2011, Versalis has been operating the business through Matrìca SpA, a 50:50 joint venture with Novamont, created to develop and manage chemical plants using vegetable oil feedstock for the production of bio-chemicals (bio-plastics, bio-lubricants and bio-additives for elastomers). Matrìca means "mother" in the Sardinian idiom, because the first plan is to reconvert the old Porto Torres (Sardinia, Italy) petrochemical site to a bio-based chemical complex. With a total investment of 500 million euro, the project consists of seven new plants - an integrated production chain from vegetable oil to bio-plastics - planned to be completed within the next six years, and a small research center (700 m^2) devoted to bio-chemistry that will be operative within 2012. Versalis plan thus to convert the Porto Torres production from traditional fossil into bio-based productions: all the traditional chemical plants at the site with the exception of nitrilic rubbers NBR will be shut down and converted to the new production. It is planned that when it will become operative (2015-2016) the total number of jobs at the site in Porto Torres will increase by 100, from 582 currently, to 685, based on an estimated growth of this sector of 17.7% per year, reaching 8.1 million tons in 2015 [2], even if today (after two years from this analyst report) it appears that the outlooks are significantly less promising. To complete the project, eni plans to build a biomass energy plant (with further investment estimated at around 230 million euros) to provide electrical power. Together with these initiatives, other were launched recently, from the agreement (Memorandum of Understanding signed in July 2012) with Genomatica and Novamont to produce (bio)-butadiene starting from renewable sources, to the creation of an Italian technology cluster of green chemistry (financed in part from Italian regions and the Ministry of Education and Research - MIUR) together with ChemTex Italy, Novamont and Federchimica (as promoting partners) with the

objective of developing bioindustries (and biorefineries) in Italy. After years of stagnation, there is thus a decisive turning of strategy of eni towards chemistry, particularly towards biomaterials (especially rubbers and components for other biopolymers) and (in part) to biorefineries. There is a parallel push to foster the concept that "green chemistry" must be somewhat limited to the literal term of green=biomass.

Bio-economy and strategies for sustainable (green) chemistry in Italy

While it is out of question that biomass is an important resource that must be used in the industrial chemical production, a scientific reflection and debate should be made on the effective possibility to introduce a bio-based "only" economy. In other words, biomass is a resource that should complement or substitute current industrial chemical production. Actual forecasts (made in the frame of Cefic) indicate that it is already a very ambitious target that 20% of actual chemical products could be made starting from bio-resources by year 2030. A more realistic target is 10-15%. Even for 2050, solid estimations do not forecast that more than about 30-35% of the chemical production could derive from bio-based raw materials. Thus, biomass will be an important resource, but not a substituting raw material.

The reasons are many:

- at least for the next 20 years, chemicals from biomass should be drop-in products, e.g. that can be inserted in the actual (or with minor modifications) production chain, due to the cost and time to introduce new competitive materials and the highly integrated character of the chemical production. This fact greatly limits the effective number of products;
- the high cost to produce chemicals from biomass, which is a complex raw material. Its selective deconstruction and transformation is quite difficult (we don't consider here chemicals which can be extracted directly from biomass, being limited in use). Up to now the bio-chemicals or bio-materials on the market are quite limited. They derive from relatively simple processes and often in the case of actual commercial biopolymers they must be blend with conventional polymers to reach the necessary market properties, if not for niche applications;
- biomass must be harvested and transported to the production site. Transport from rather far areas could be necessary. Biomass growth is subjected to stagionality, and fluctuations in growth/quality, while chemical production needs continuous supply and quality. These problems can be solved, but increase the costs;
- land availability for biomass growth is an issue not enough discussed. It is often indicated the availability of marginal land, for example in Italy, but these statistics do not account for the availability of land which can be effectively used for industrial biomass production, which is much more limited, because requires mechanical harvesting, availability of water, etc. Waste biomass can be a resource, but often estimations include materials which are currently utilized differently (for example, in Campania region the agricultural waste is used to feed the animals to produce the Buffalo Mozzarella). In addition, a chemical plant based on waste can accept some different type of biomasses, but not all. Thus, often the data on the availability of waste overestimate those effectively available for chemical production;
- environmental impact of agriculture and biomass transformation. Intensive growth of biomass has a market impact on soil, determining progressively an extensive use of fertilizers, and on the water cycle, with the pollution associated to use of fertilizers, pesticides and other necessary chemicals, and water use for irrigation. In the regions when rate of biomass growth is high due to the favorable climate, there is scarcity of water. Bioproducts have also a large impact on CO_2 emissions (particularly those based on fermentation), rather than contribute to decrease them.

All these motivations concur in indicating that the chemicals deriving from biomass, particularly if the latter should be of European origin (to favor European agriculture, as discussed currently by European Parliament), cannot overcome a value of about 20-30% of the total. If this consideration is correct, the question is whether the future of chemical production in Italy should be "only" in bioeconomy or a different (more complete) strategy is necessary.

Tab. 1 - The first 40 chemical companies in Italy (with majority of the societal capital in Italy; pharmaceuticals are not considered) and their production in Italy in year 2010 in million Euro (source: Federchimica)

Company	Production in Italy (year 2010), M€	Company	Production in Italy (year 2010), M€
Polimeri Europa	4821	Isagro	104
Gruppo Mossi & Ghisolfi	383	Esseco Group	104
Gruppo Mapei	744	Montefibre	-
Radici Group	605	FIS - Fab Ital. Sintetici	178
Gruppo Bracco	527	FACI	80
Gruppo P & R	487	3V Partec. Ind.	93
Polynt Group	483	Reagens	81
Gruppo COIM	327	Indena/Gruppo IdB Hold.	115
Gruppo SOL	302	Inver	91
Gruppo Colorobbia	211	Alcea	80
Gruppo SIAD	265	ICR - Ind. Cosmetiche Riun.	121
Gruppo Aquafil	249	Sinterama	62
Gruppo Sapio	414	Index	116
Gruppo Lamberti	253	Zach System	77
Dobfar Holding	271	Silvateam	80
Gruppo Sipcam-Oxon	142	Gruppo Bozzetto	65
Intercos Group	134	Deborah Group	82
Gruppo Zobele	54	Paglieri	104
Sadepan Chimica	185	Sabo	103
Gruppo Desa	210	Syndial - Att. div.	101

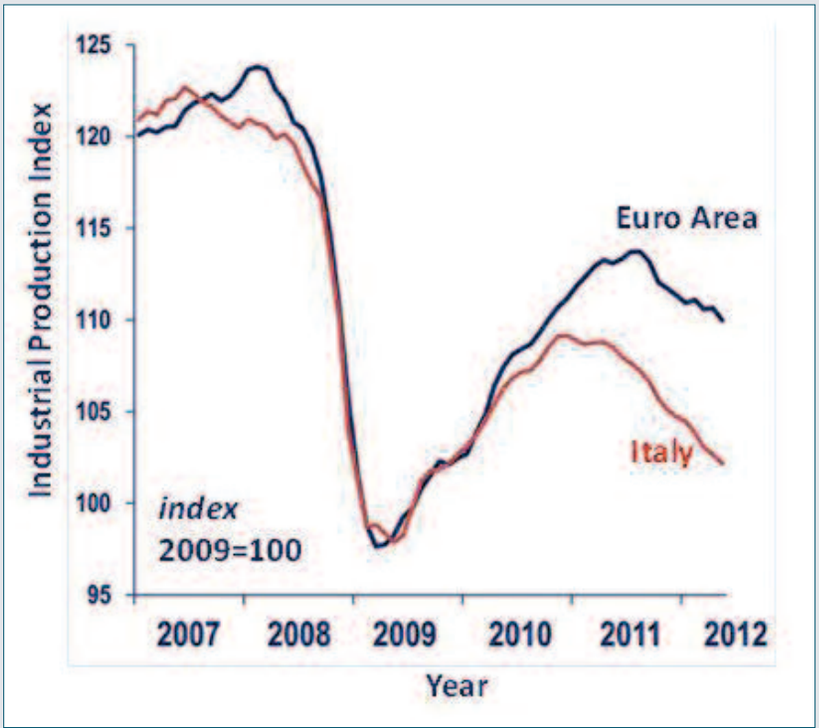

Fig. 1 - Trend of chemical production index in Italy and in Euro Area. Data are correction considering inflation rate. Source: Federchimica (based on Eurostat/Prometeia)

When we discuss about chemical production in Italy, there is a variety of different type of productions and companies. Tab. 1 reports the first 40 chemical companies in Italy (with majority of the societal capital in Italy; pharmaceuticals are not considered) and their production in Italy in year 2010. Polimeri Europa (Versalis) has about one order of magnitude higher production than the average of the others, and a clear push towards a bioeconomy by this group (in addition to other major groups such as Mossi & Ghisolfi) will have a major influence on all activities related to chemistry in Italy.

The status of the chemical production in Italy

A discussion on the strategies for chemical production in Italy should start from an analysis of the current status, using official data from Federchimica (the Italian association of chemical industries) [3]. We can recall here only some aspects relevant for the discussion.

The first part of 2012 has seen mixed results depending on the business area. Some areas, such as phenol and derivatives as well as chloro-soda and other inorganic chemicals, were relatively good, driven mainly by demand from the Asia, while the markets for plastics (polyethylene and polystyrene) showed drop in demand. Polyolefins (-6.5%) had a significant drop, being for about 56% market in Italy. LD/LLDPE decreased by 8.5% due to the decrease of market for extrusion films, HDPE decreased by -6.5% for the lower demand in extrusion tubes, PP is decreased by over 5% due to the lower demand in several sectors, particularly those of fibres. Strong decreases are shown by polyurethanes (-12%), rigid PVC (-8.6%), PS (-7.1%), EPS (-10%), PA (-5.8%) and PET (-5.1%).

Agropharmaceuticals have instead growth by 1.7% with respect to 2011. Also intermediates, fine chemicals and specialty products (such as catalysts) have a positive trend.

Fig. 1 shows the trend of chemical production index in Italy and in Euro area. After the 2009, it was a good recovery in 2010, but the economic general crisis influenced negatively the trend in 2011 and first half of 2012. However, it is evident the presence of a specific weakness of the situation in Italy as compared to the average in Euro area. Fig. 2 shows for the chemical production in Italy (a) the trend of internal and external sales and (b) the production prices on internal and external market. The data show that the export is driving the chemical production, but this is not related to the presence of competitive prices. Thus, without export, particularly to Asia, the crisis of the chemical production in Italy and loss of competiveness with respect to the Euro area would be even more severe. This is confirmed from the analysis of single market areas of chemical products. Those more weak on the international market had a more severe decrease in 2011 and first half of 2012.

A longer discussion and more in depth analysis would be required, but not possible here. We may conclude that the capacity of being competitive on the Asia market is a key element for the chemical production in Italy, but should be present a focus on strategic sectors for this area, when the market is not already saturated, such as in in the polymer sector.

Bio-polymers could be a winning strategy in this direction? If they remain a niche production area, as the current situation (few % of the total polymer production), the market demand responds to different logics and can accept higher production costs (as today). However, it is not possible to consider a strategy for chemical production in Italy limited to only niche products. A question mark should be instead put on the possibility that biopolymer production will be the backbone of chemical production in Italy. There are many weaknesses, from the absence of enough raw materials to the limited dimension of chemical companies in Italy (to create a wide range of portfolio products), to the scarce relations between academia and industry that favor a rapid transfer of idea to innovation. Current strengths of chemical industry in Italy are related to process engineering, production of advanced tailored materials, high technical skills of workers.

A strategy for chemical production in Italy should valorize these strengths, giving adequate importance to biopolymers and other bio-based products, but maintain a strong presence on traditional areas which feed with important products the manufacture processes. For example, acrylic acid is the basis for the manufacture of superadsorbents, used in many applications, including for example water purification treatments. In Italy, leading companies in the latter sector are present, but they need to have access to acrylic acid at competitive costs, while companies producer of acrylic acid sell on free market at higher costs (up to over 30%). On the other hand, low cost acrylic

acid, produced for example in some Asian countries, has often not the necessary quality (constant with time). The idea that chemical products can be purchased on the free market and there is no need of national chemical industry has thus revealed the limits in the approach. The presence of a strong and competitive chemical production in the country is a critical element to stabilize the prices and be thus a pushing element for the entire country manufacture sector.

Sustainable chemical production in Europe

In order to complete this brief discussion on the strategies for chemical production in Italy, it may be good to recall what is on-going in Europe, particularly at the level of Cefic which represents the best perspective point of view, even if the Italian companies (except Mapei) have been not active in the various initiatives promoted by Cefic, particularly regarding sustainable chemistry.

A key reference regarding the strategies of chemical industry in Europe, is the roadmap on SPIRE recently published [4]. SPIRE (Sustainable Process Industry through Resource and Energy Efficiency) is a proposal for a Public Private Partnership (PPP) driven by the European Process Industry (mainly, but not only, chemical industry) and fully aligned with the strategic goals defined by the European Commission in the Europe 2020 vision paper.

The SPIRE PPP will be instrumental in addressing the Grand Societal Challenges defined within the EUROPE 2020 Agenda through the broad correlation that SPIRE has across various flagships initiatives (Innovation Union, Resource Efficient Europe, New Skills for New Jobs and Industrial Policy for the Globalisation Era).

There is a second PPP on Biobased Industries (Biobased for Growth) under development, where different chemical companies are present (Novamont and Chemtex for Italy) and Cefic/ETP SusChem between the associations, but the nucleus of largest European chemical companies (BASF, Bayer, Solvay, Evonik, etc.) is present in the PPP SPIRE.

The realization of SPIRE is considered essential in order to rejuvenate the European process industry base and make the paradigm shift of decoupling economic growth from resource impact (a critical element

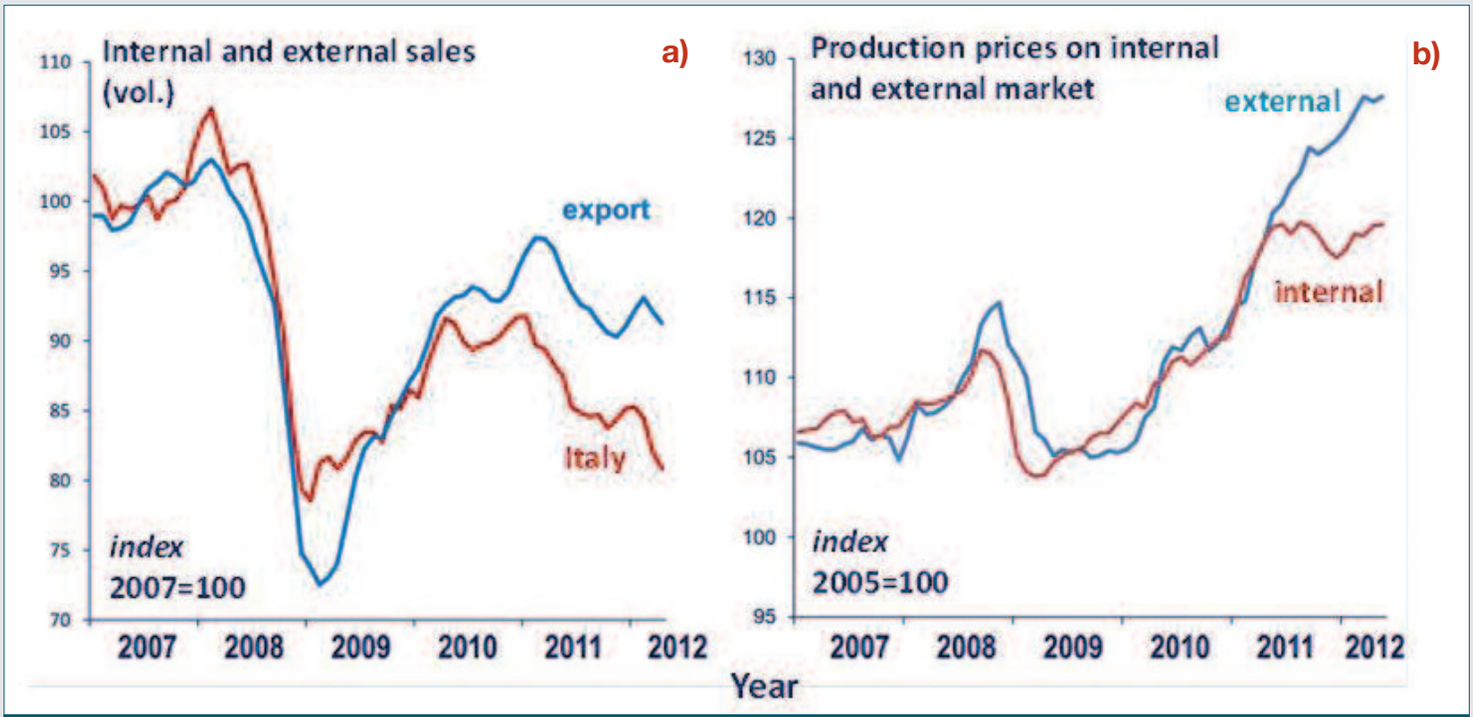

Fig. 2 - Chemical production in Italy: a) trend of internal and external sales and b) production prices on internal and external market. Data are correction considering inflation rate (source: Federchimica, based on Istat)

for sustainability). Therefore, together with an initiative to foster a bio-based economy, European chemical industry saw the importance to focus R&D activities on energy and resource efficiency, as a viable strategy to drive innovation, bring cost reduction, increase productivity, product quality and competitiveness, while at the same time disconnecting growth from its environmental footprint. The challenge will be to exploit new business opportunities resulting from the transition to a more sustainable, resource efficient and low carbon economy as stated in the Europe 2020 Flagship Initiative "An industrial policy for the Globalisation Era" [5].

Industry will need to develop processes for a complete range of new products and services, based on high longevity of materials and products, low embodied water, as well as low-energy and material content. This will be achieved through a transition of industrial processes, to become less carbon and material intensive while at the same time preserving jobs or reinvesting in completely new employment opportunities.

SPIRE roadmap provides a pathway for the Process Industry to decouple human well-being from resource consumption. This is at the heart of a transition to a Green Economy.

Together with attention to an optimal valorisation and smarter use of existing, alternative and renewable feedstocks (thus not only biomass, but other potential feedstocks such as shale and stranded natural gas resources, and all type of wastes, not only organic, from inorganic to water and CO_2), SPIRE roadmap put attention on processes as key component, from novel advanced energy systems (including an efficient introduction of renewable energy, energy harvesting, storage and reuse) to advanced process technologies to improve the use of resources and energy (with process intensification, use of catalysis, and process integration as key elements). It is necessary to develop new materials for improving processes, as well as redesign materials for an intrinsic reduced energy and CO_2 footprint.

A sustainable (green) future for chemical industry derive from investing R&D on all process chain, from the smart use of resources to the advanced process and to the full valorization, in an integrated (symbiosis) manner of the products. This is an evolution of the way in which chemical industry has been grown over the past. Focusing attention on a single element, even if perhaps relevant such as the use of biomass, may be a great risk and an element to loose competiveness, instead to create and strength chemical industry in Italy.

Conclusions

Chemical industry is moving, but in the right direction? After years of stagnant situation, differently from other European countries, it is already positive a signal of movement. However, for the same reason it is useful to start a reflection and discuss about the strategies for a sustainable (green) chemistry in Italy.

This contribution cannot give solutions, and will only stimulate a debate. However, it is remarked with some worry that a reduction of the vision for chemical production to one based only on biomass resources may be not the right strategy for Italy. We have commented that this approach does not look winning neither in terms of analysis of the market strategies nor in terms of integration with the European vision. It is not under question that bio-economy is relevant, but that only bio-economy is relevant.

Chemical industry is strategic for the country, but when it is fully integrated with manufacture. This requires a holistic approach which doesn't fit with the idea of bio-economy as the only driving element for the future of chemical industry in Italy.

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