Radiation Curing in Europe

by H.Hilmar Bankowsky, Klaus Menzel, Manfred Biehler; BASF AG D 67056 Ludwigshafen

It has taken over 20 years in Europe that Radiation Curing has become an established technology in industrial coatings and graphic arts. Today it is regarded as compliant and best available technology that has already substituted mainly solvent-borne systems. Besides good performance properties of the coatings and high ecoefficiency of the process and other factors like chemical legislation have played an important role for the success of radiation curing.

Driving forces for radiation curing

Performance
- High surface quality
  - Chemical and mechanical resistance
  - Gloss, scratch- and abrasion resistance

Economy
- Energy and material saving process
  - Cold cure, no additional heating

Ecology
- Nearly no VOC's
  - Very low emissions after curing
  - Very low extractables after curing

Market

Compared to the total resins market for industrial coatings and inks the share of radiation curable products is still small and will remain rather small even at higher growth rates than the average market. Other compliant technologies like powder and waterborne will also take their share at the expense of solvent borne coatings.

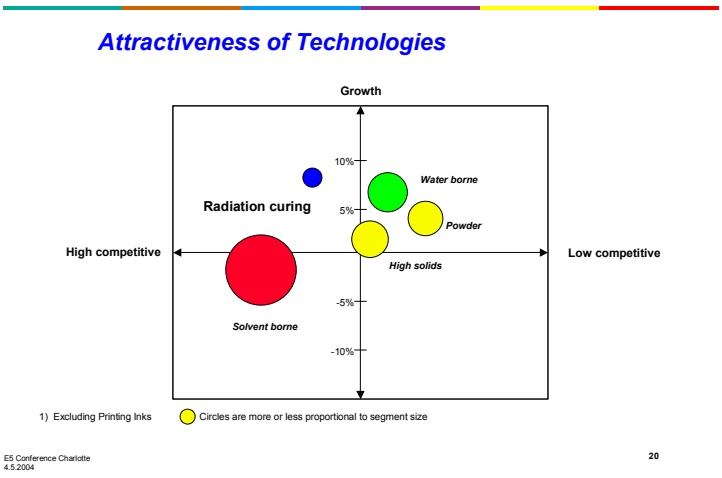
Market Radiation Curing in Europe
- Acrylates -

k tons	2003			2010			AGR
	conv.	UV	Share UV %	conv.	UV	Share UV %	%
Gen. Industry	503	0	0,0	589	5	0,8	n.a.
Wood	244	27	11,1	286	43	15,0	6,9
Anticorrosion	146	0	0,0	172	0	0,0	n.a.
Auto OEM	146	0	0,0	172	2	1,2	n.a.
Auto Rep	73	0	0,0	86	4	4,7	n.a.
Can/Coil	73	0	0,0	86	4	4,7	n.a.
Others	220	3	1,4	257	6	2,3	10,4
Graphic arts	416	23	5,5	487	35	7,2	6,2
Total	1821	53	2,9	2135	99	4,6	9,3
				AGR Total Industrial Coatings			2,5

E5 Conference Charlotte
4.5.2004

6

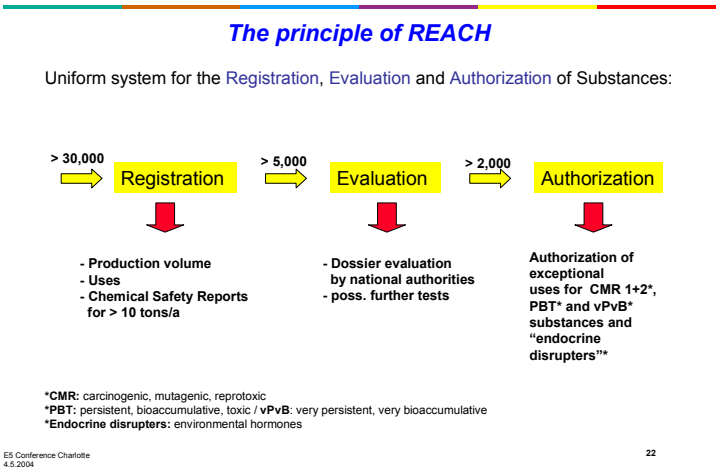
The small share the other hand means a huge potential for further growth in the market. Technologies that meet the stringent requirements related to chemistry legislation will displace the old ones. Radiation curing with its versatility of applications has the best chances to succeed. Further product developments, special additives and curing processes are necessary to widen the horizon for new applications and to keep the technology attractive.



In Europe legislation regarding chemistry and safe use of chemicals have helped to further develop radiation curing and will continue to do so in the next years. One example of important legislative regulation that will also affect importers to Europe in the coming years is the Future EU Chemicals Policy. It started when EU Commission published the so called White Paper in 2001 that proposes a uniform regulatory system for existing and new substances under the principle of REACH

Registration
Evaluation
Authorisation of Chemicals

The motivation behind is to protect human health and environment. All substances with a consumption above 1 t/year have to be registered by manufacturers and importers and there will be no differentiation between new and existing substances anymore. After a transition period for existing products of 11 years EINECS will no longer exist. Polymers according to the OECD definition will be initially exempted from this system.



Every company producing and processing chemicals will have to face this new situation. RadTech Europe Organisation is thoroughly following up this matter and is actively involved in this process because the effect on our industry is considerable. Together with CEFIC, the European Association of Chemical Industry, CEPE, the European Association of Paint and Ink Manufacturers, and other organisations, e.g. German Berufsgenossenschaft of Printers a lot of actions have been taken up. Some examples are:

- Labelling guide of UV/EB Acrylates
  UV/EB Acrylates Sector Group at CEFIC
  http://www.cepe.org/eas/easpdf/0104AC.pdf
- UV Protocol of safe handling of inks
  German Berufsgenossenschaft Printers
  http://www.radtech-europe.com/UVProtokol.html
- Uvitech Project that proves safe application of inks
  Supported by EU
  http://www.radtech-europe.com/uvitech2004.html
- Various ecoefficiency analysis on coatings and inks

Another burden for the end user industry is the reduction of VOC's. A great number of smaller and medium-sized end-users will have difficulties to meet the deadline of requirements for VOC reduction in 2007 unless they switch over to compliant technologies mainly radiation curing. A pre-requisite for this change is that existing technical problems must be solved. For the raw material producer, the formulator and the machine designer it means that a lot of efforts have to be shown in R&D in order to foster sustainable development.

This future business environment is therefore a great challenge for companies involved in R & D. They have to widen the existing applications with product modifications or new products. New applications with new products and processes must be elaborated and a lot of work in this direction has already been done.

We assume that following targets are pursued in many R&D plans for the next years.

Wood coatings
- Products with less extractables
- Products with high scratch resistance
- Spray coating of 3 D objects

Graphic arts
- Inks and OPV's with approval for food packages
- Inks and adhesives for DVD's
- Ink jet

Plastic coatings
- Adhesion promoters

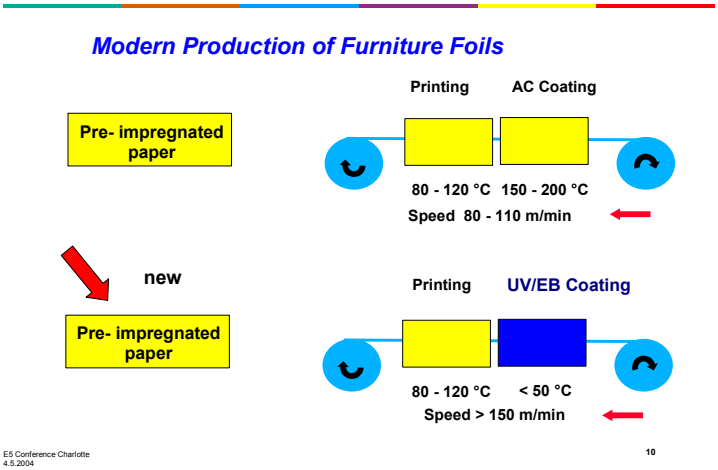
Metal coatings
- Products with good adhesion
- Products for coil coatings
- Weather resistant coatings for
    - Automotive OEM
    - Automotive refinish

Most of these new targets require new products like waterborne systems or dual cure resins.

A surely incomplete selection shows what future trends have been achieved so far and what developments in Europe can be highlighted.

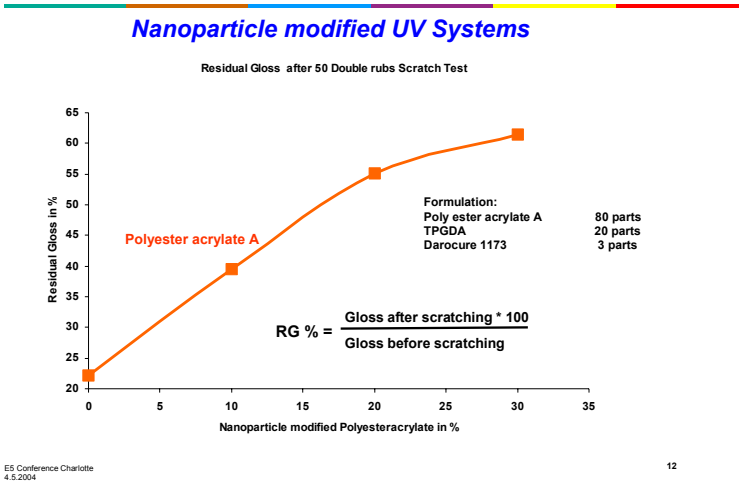
Example for a technology switch towards radiation curing

Furniture foil (laminated surface) is a printed and coated paper that is glued on chipped board as decorative surface. Coating of furniture foils is conventionally done with an acid catalyzed water-borne system of melamine resin/emulsion combination. Major drawbacks are high energy consumption for the curing process and emission of formaldehyde. With a radiation curable coating the process is much more simplified and more economical.



UV coatings with high scratch resistance [1]

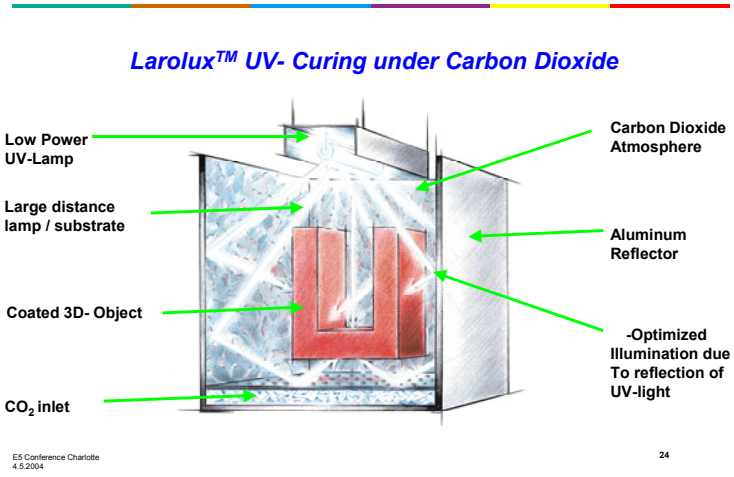
Apart from decorative effects a coating mainly has to protect the surface. Coatings for parquet flooring for instance require besides high abrasion resistance also scratch resistance which is nowadays the major focus in formulation development. Surface hardness is the key to achieve this target. There are two ways to accomplish this. One is to cure under inert atmosphere where a higher rate of conversion yields to harder surfaces. The best results are obtained by incorporating additives like nano-scaled silica in situ incorporated to a polyester acrylate.



Spray application for 3 D ojects [2]

UV coatings are mostly applied onto planar substrates where lamp distance to the substrate is constant and the dose of energy applied is evenly distributed. When it comes to curing of 3 D substrates the process is much more complex. Because of different distances between surface and lamps the dose of irradiation varies. The idea overcome the problem was to cure under inert atmosphere that avoids oxygen inhibition of the curing and thus yields to a better through-cure of the coating.

By designing a device in which a pool of Carbon dioxide is captured in a tunnel lined with aluminium foil as a reflector an easy way to cure 3D substrates was found.

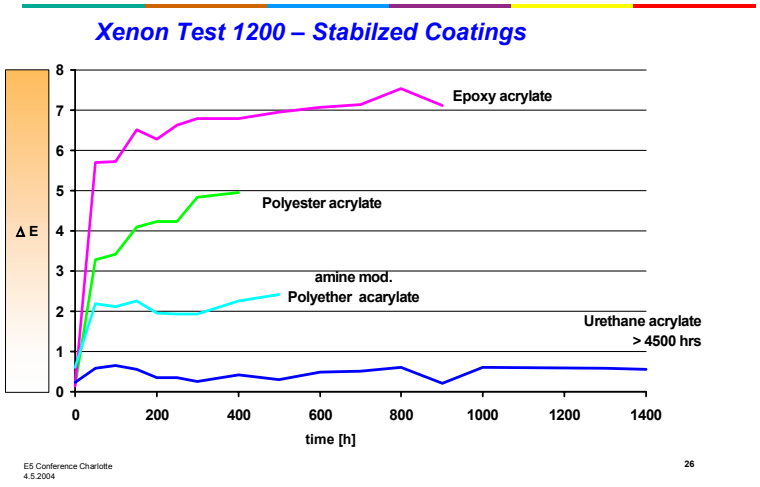


UV Curing of pigmented systems [3]

To enter into additional market segments with pigmented UV coatings some obstacles have to be overcome. Unfortunately there is a competition in the coating between pigments and photoinitiators when exposed to UV light. The ideal pigment should have good UV transparency in order not to interfere the photoinitiator reaction and good absorption in the range of 400 to 700 nm in order to provide good hiding power. With a smart combination of photoinitiators absorbing UV light between 380 to 410 nm, suitable lamps (Ga- or Fe-doped) and curing conditions most of the pigmented coatings can be fully cured. By using a dual cure process the remaining restrictions can be eliminated.

UV coatings for outdoor exposure [4]

In the past the dogmas: UV cured coatings cannot be stable against UV exposure and UV stabilized coatings cannot be UV cured have suppressed developments in this direction. Recent results have shown that by selction of wavelength specific photoinitiators an UV protectors both UV curing and UV protection can be achieved at a time. Combination of binders which do not contain chemical structures that are destroyed by UV light neither ingredients with tendency towards yellowing formulations with excellent weather resistance are feasible.



Conclusions

Today the most efficient and economical way of developing new products, applications or totally new systems is to do this in a joint effort of all market participants. Even the end-user should be involved by showing what radiation curing technology can help them to be successful. Over the last years the following trends in customer relationship could have been recognized.

Trend at raw material suppliers

- Active participation in panels to follow the changes in legislation related to health, safety, working hygiene and environment
- Become a solution provider to customer‘s problems
- Work on segment and customer specific innovations
- Globalization of services and standards

Trend at coatings manufacturers

- Short lead-time to meet new legislative regulations (VOC, Preparation Directive, etc)
- Reduced numbers of suppliers and raw materials
- Transfer formulation development towards the raw material supplier
- Provide package of services and problems solutions
- Even smaller companies must become global

Trend at end-users

- Short lead-time to meet new legislative regulations (VOC, Preparation Directive, etc)
- Reduced numbers of suppliers
- Transfer of development activities towards the coating manufacturer

1. M. Biehler, e.a. Proceedings RadTech Basel, 2001
2. E. Beck, Proceedings RadTech Berlin, 2003
3. K. Menzel, e.a. Proceedings eI5, Charlotte, 2004
4. R. Königer,e.a. Proceedings RadTech Berlin, 1999