

THE FUTURE OF ADHESIVES AND SEALANTS SEEN FROM A EUROPEAN PERSPECTIVE

Jürgen Wegner, Ph.D.
Director, ChemQuest Europe
Düsseldorf, Germany

The ChemQuest Group, Inc.
Cincinnati, Ohio

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There is no such thing like an all-purpose adhesive, this kind of multi-talent that works on each and every substrate, that strongly bonds every type of material, endures all and even the most aggressive chemicals, climates, forces, decompositions, distractions, and you name it.

This versatile animal simply does not exist. But once the frame conditions are specified, and given that some base rules of joint engineering and design for appropriate stress distribution combined with proper substrate preparation are observed, virtually every combination of materials can be adhered today, and in many cases outperforms any other bonding technique if the right, highly specified adhesive designed for just this particular job is being utilized.

The buzzwords apart from adhesive formulation are joint design, substrate preparation, and knowledge of future exposition and frame conditions translated into the appropriate adhesive formulation coupled with the “right” adhesive application technology. If you precisely know what to adhere under which circumstances for what span of life you expect, the more precise the answer will be. And mother nature shows us with striking examples, how effective, specific and sophisticated structural bonding can be, and we also see with geckos, ants, spiders and insects, how Van-der-Waal’s is for ages smartly put into place.

With man-made adhesives, knowledge is key, and the more we know, the more likely we are able to make those seemingly obvious contradictions intelligently make to work and overcome like “water-born, but water resistant”, “lighter in weight, but superior in structural rigidity”, “highly reactive but toxicologically unobjectionable”, “extremely fast curing, but virtually unlimited in shelf stability”, “adhesion to non-adherable low energy surfaces” and so on.

Inherent problems perceived as being virtually built-in and insurmountable as of today might be settled as a state-of-the-art tomorrow, just as we hope to tackle “bonding and debonding on command” one day, where structural adhesives strongly bond until at will – you hear it right: at will - a “switch” is pulled to have the adhered parts to fall apart.... Debond-on-Command to remain a day dream? I do not think for too long anymore....

Europe is world-class in environmental sustainability and energy-efficient technologies with a broad spectrum of applications and industries involved where technological progress would simply be impossible would we not have or take care to have the right adhesives and sealants in place! Lightweight multi component car



bodies, just to give one example, combine high crash resistance with fuel efficiency unheard of just a few years ago, wouldn't do without adhesives and sealants. Same holds for high speed trains, modern ship building, new aircraft design, new truck and trailer technologies, just to mention transportation as one of the many industrial sectors involved, or take a look at building construction, electronics, packaging, white goods, textiles, just to name a few. Towards the end of my presentation and if time allows I will come back to just a handful of practical applications that will support my optimism, that the 21st century is about to become THE adhesive age, not the beginning of the end. Adhesives are all but not a mature technology!

All natural resources, not just crude oil will become both, scarce and expensive in the foreseeable future, so that energy efficiency coupled with efficient usage of all necessary resources plus a true material re-cycling (not down-cycling!) will become a fundamental element of all relevant technologies – and calling for bonding techniques that permit disassembly of those multi component devices at the end of their service life as a fundamental pre-requisite. The three R's of the future, that Joseph Coates was referring to as a keynote speaker at the ASC Summit in Cannes this Summer offer outstanding opportunities for adhesives and sealants, and where Europe for the time being certainly sits in the drivers seat: The R's stand for Recycling, Reclamation, and Remanufacturing of goods.

One also does not need to be a prophet to forecast that renewable resources will increase their share as base components for adhesives and sealants in future, as will the precise dosing of ever tinier miniature droplets of adhesives with respect to the exact position and amount - a challenge that for sure will be met. Adhesives and sealants are an important segment of applied polymer chemistry, no matter if the monomer base is man-made or natural. Whereas the likelihood is considered minimal that completely new chemical alternatives will be discovered on the synthetic frontier over the next decade or so, a better understanding of natural adhesive strategies and their replication will one day certainly lead to a new class of reactive, most likely protein-based "bio" adhesives, not to forget hybrid combinations thereof. On the synthetic side Polyurethanes and Silanes to my estimation still bear the highest potential for new discoveries through both, chemical modification and physical blending. The spectrum of adhesive applications especially in industrial sectors expands every day, but this does not automatically translate into higher tonnage, as better physical dosing and positioning plus better adhesive performance with standard applications will partly offset this trend. But in the end, it's value to the customer and not tonnage that really counts, as the more specific an adhesive is designed to do a superior job to a



specific customer, the less we talk about the price... And the more likely we act as a solution provider rather than just another adhesive expert, the more likely we talk about profitable, lasting, and loyal customer relation where we become an integral part of their innovation process right from the beginning of their first sketch at the drawing board. Once adhesives and sealants are positively fixed in the minds of design engineers and opinion leaders, and that they precisely know about their Pro's & Con's, only then have we really done our homework. Europe in this respect is far ahead, but I see our American friends with their AFI (Adhesive Fastening Institute) program rapidly progressing too, and I can only invite today's audience from Asia including our host China to join the bandwagon too, and we will be happy to share our tools and experience with you. Adhesive knowledge is a global issue requiring a long "curing time" to bear fruits pursued by a highly globalized industrial branch, and that is the reason why we invite you to join.

From a European perspective with all that I just have put in rather broad terms onto the table I expect the following overall trends:

- **Base components for adhesives and sealants:** Progress in polymer chemistry may look exhausted at a first glance, but innovations can be expected from ever new combinations of already existing monomers, polymer backbones, new curing chemistries and smart curing technologies i.e. laser-, microwave or induction-induced, the combination of man-made with natural polymers, the better understanding of biological bonding and their targeted implementation into new structural bonding techniques, and finally the use of highly specific and effective enzymatic catalysts. As mentioned before, on the synthetic side I still see innovation potential in Silanes and Polyurethanes through both, chemical modifications and physical blending. I expect a renaissance in polysaccharide chemistry, the use of organic molecular spacers, and natural fats and oils that systematically will be exploited for their potential as base material for adhesives and sealants just as coating and paint chemistry shows us. To a certain extent contrary to the rest of the world, however, VOC replacement is state-of-the-art in most of Europe, and bears no real innovation potential any longer.
- **Nano:** The Nano-age hasn't even begun as yet, although it most likely will have a dramatic impact on adhesives and sealants, as it is anticipated to revolutionize many other fields as well. Be it the permanent modification of wettability and thus adhesability of low energy substrates, high-solid polymer nano-scale emulsions, nano-scale fillers and their unique impact on rheology, on preservation, on permeability, and on coloring, the potential goes much beyond today's imagination. Researchers all over the world work on that, and currently take their claims.



Even disbond-on-command may come along this way, as patent claims and the literature tells us.

- **Application and pre-treatment techniques, dosing technologies:** Typically the pre-treatment of substrates especially in preparation to structural bonding is by far more costly and labour intensive than the adhesion itself. Innovations in this field such as corona, laser and plasma techniques have a direct and immediate impact on both, performance and costs. Adhesive spreading becomes more sophisticated every day, where precise placing of the exact micro amount of no-string adhesive at exactly the right quadrant of a specimen under high-speed assembly line conditions is paramount. Any progress in spraying and printing techniques will immediately be adapted to adhesives and sealants, as is today's state-of-the-art. On Nano-scale, self assembly will become the technique-of-choice, as mother nature proves.
- **Application areas:** Each of the foreseeable trends like the drive to higher energy efficiency, multi-component structures, recycling without down cycling, the three R's I was talking about earlier, miniaturization not just in electronics alone, the highest possible cost efficiency calling for mass assembly line production of goods all require adhesive bonding as the joining technique-of-choice, and becomes even more logical if a combination of those elements is to be addressed. European high tech products like the double deck Airbus giant A 380 making its maiden flight within the next few month would never get airborne nor show the fuel efficiency predicted wouldn't major structural multi-material components be adhered, as proofs the body of the current BMW 5 series consisting partly of steel, partly of aluminium. With modern car design and manufacture the easy equation is that over-proportionally to weight reduction the usage of adhesives and sealants grows. **Adhesion bonding is an enabling technology across almost all industrial production processes, not to forget craftsmen and DIY.**
- **Curing techniques:** UV, moisture, aerobic, non-aerobic, light and laser curing are quite common features to kick off the reaction mechanisms of multi-, usually two component systems, as is exothermic or external heat and the release of a micro-encapsulated curing catalyst, which all leads us away from straight forward mixing of 2 component systems. Further refinements and improvements are likely and must fit to the bonding specifics, plus customer requirements in terms of speed, space, work conditions and safety requirements, reliability, reproducibility, and finally cost.
- **Regulatory obstacles:** At the first glance excellent news to our Chinese guests, to our other Asian, African, American and non-EU European friends: Should REACH, an initiative from the European Union ever become a reality, and the chances are



pretty good, then Europe will lose most of its present competitiveness, and will become inundated with costs and bureaucracy within the whole of our industry: REACH stands for Registration, Evaluation, and Approval of Chemicals, and will require a time consuming and costly testing of not only the individual chemicals, but their preparations like adhesives as well. And this virtually independent of their tonnage, exposure and risk potential. Immediate result will be that many low-tonnage raw materials will disappear from the markets – which however often are indispensable to formulate those top quality low tonnage adhesives for the highly specialized application niches I was talking about earlier. A lot of R&D investment will thus be needed just to maintain the status quo, but at what price? Figures ranging from 2.5 bn EUR to 15 times that high are in discussion for the next 5 years, and nobody knows the truth. It is expected that many small to medium sized enterprises SME will have to give up, by this further driving the concentration process within our industry. As a result, we see a scenario where the costs for sure will go up without creating any noticeable benefit neither to the environment nor to product safety, but partly blocking the innovation process within Europe, and all that at the expense of global competitiveness, and to European SME's. But be cautious before you non-Europeans start to applaud: Chemical imports into the EU zone will undergo very rigid measures too, although nobody knows how this could be achieved without violating international trade treaties, but the message is clear: It will “reach” you too, should REACH ever become a reality. And NGO's all over the world just take Europe as a scapegoat to launch similar programs in other regions as well. Thus global solidarity among us is the ultimate name of the game and the louder and more substantiated we oppose REACH all together the better it is for all of us. Let's make one thing quite clear, however, and that is that opposition against REACH in its present form does not mean that we as manufacturers of adhesives and sealants would ignore to take full responsibility to assure with our adhesives and sealants the best possible practice in product, occupational and environmental safety (SHE). Here we do not allow for any compromise, as it could tarnish the image of our industry as a whole, and would prevent the potential use of our products.

- **Education, Quality, Norms:** The most crucial points for higher acceptance and a better public image apart from related SHE issues are: certified education, quality assurance, and truly binding norms and specifications! About 10 years ago within Europe Germany lead the way in inaugurating several programs to foster the spread of knowledge on adhesives, and established among others with FEICA (the trans-European Adhesives & Sealants Association based in Düsseldorf), the German IVK (the national Adhesives Association), and DVS (the German



Welding Association headquartering in Düsseldorf too) quite a number of different modules and teaching programs on several levels of education all having in common that appropriate usage of adhesives requires knowledge first. **Only by precisely knowing what adhesives do and don't the design engineer to a new product on our customer's side will consider adhesion preferential to mechanical fastening, and will make sure to do it right from the very beginning.** Architects systematically need to know about adhesives and sealants to create modern, light weight architecture without nightmarish and costly repairs over time on facades, windows, the interior and roofing. And any complaint no matter if of public domain or not may become a PR trauma for adhesives in general tarnishing our image. Thus education is paramount and a long-term investment, and in Germany thanks to IFAM and IFF the "Certified Adhesives Engineer" just has been established as the most advanced module where candidates have to pass exams after 8 weeks of intensive theoretical and practical training. And where the use of adhesives in sophisticated areas of structural bonding requires this kind of certification on workshop level to assure a sustainable quality level. This is a concept from which other countries could easily benefit, as our American friends are just about to do with their great AFI initiative. Do not re-invent the wheel, but let's join forces to learn from each other, and this should be considered an offer to our contenders outside of Europe and North America as well. Teach united, and the long-term benefit will be ours. Only 16 % of all fastening jobs are done with adhesives today, thus the potential is really enormous! Lets tackle that, lets go for water-tight quality assurance, and lets close the gap on a global basis in those areas where norms and specs are deemed necessary to set up minimum standards without undermining competitiveness and innovation dynamics: Then we are on the right track, and Europe for sure will share its advanced position on the educational learning curve with whoever is interested!



About the Author



Dr. Jürgen Wegner,

**Director, ChemQuest Europe –
Düsseldorf, Germany**

The ChemQuest Group, Inc.,
(www.chemquest.com)

an international strategic management consulting
firm specializing in the
Adhesives, Sealants and Coatings industries,
headquartered in Cincinnati, Ohio, USA.

Dr. Jürgen Wegner's expertise in global adhesives technology spanned 30+ years of experience in the chemical industry focused in adhesives, sealants, coatings, wood preservatives, and construction chemicals. Dr. Jürgen Wegner, former Global Vice President of Adhesives Technology for Henkel KGaA, joins ChemQuest as one of its European consultants in Düsseldorf, Germany. Previously, Dr. Wegner was General Manager of a \$150 million core business unit of Henkel. His knowledge spans global business perspective, strategic technology planning and general business management. Dr. Wegner holds a Ph.D. in Chemistry from Munich University and attended several management courses at INSEAD Business School in France.

Contact Dr. Jürgen Wegner at chemquesteurope@chemquest.com

Questions or request for additional copies of this paper may be directed to the author at:

The ChemQuest Group, Inc.

8150 Corporate Park Drive

Suite 250

Cincinnati, OH 45242

(513) 469-7555

(513) 469-7779 – FAX

www.chemquest.com

