

IV Cyanoacrylate Adhesives

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A Cyanoacrylate Adhesives

1 Description

1.1 Description of Products and Properties

Cyanoacrylate Adhesives – short CA – are also known as super glues. Cyanoacrylates are well established in the modern adhesive industry. The most important properties of Cyanoacrylate adhesives are:

- ▼ **one component adhesives and therefore easy to handle systems,**
- ▼ **solvent free,**
- ▼ **very fast setting time.**

First of all Cyanoacrylate adhesives are used to bond metals, plastics, wood and elastomers. By the way, the first Cyanoacrylate adhesive – Eastman 910 – was developed by Eastman Kodak in the 50ies of the last century.

Due to their extraordinary adhesion profile – one component, solvent free, very fast setting – Cyanoacrylate adhesives still today reflect the users' needs. As modern reaction adhesives Cyanoacrylates have established themselves in overall industry proved by years of experience and by positive results. Today there is a wide range of materials in industry that need to be bonded. Cyberbond is developing its Cyanoacrylates continuously to guarantee best results for industrial users. It is important to offer suitable products with good storage conditions.

Parts bonded with Cyberbond will give the user reliable mechanical strength, good overall strength properties on most non porous materials, sufficient temperature resistant figures, improved elasticity figures, good ageing and climatic properties as well as a resistance against ozone. Cyanoacrylates polymerize within seconds due to the humidity in the air. To reach optimal results it is important to work with thin adhesive layers and to keep the mating parts as small as possible as the adhesive reacts very quickly.

Very quickly the industry recognised the performance of Cyanoacrylate adhesives. Due to its efficiency in production the relative high costs of Cyanoacrylate adhesive at that time could be neglected. Thus, success of Cyanoacrylates could not be stopped in the industry anymore. Constant improvement in quality and new production techniques allow the user to choose from a vast variety of different Cyanoacrylate adhesives. Generally, Cyanoacrylates can be depicted as a colourless, clear liquid with a slight distinct smell.

1.2 Chemical Basis and Viscosities

There are two main issues manufacturers of Cyanoacrylate adhesive differentiate between and which we would like to dwell on.

First of all there is the chemical basis. We are talking about the so-called monomer, which determines the suitability of the adhesive for a special application. We distinguish in different Ester groups in which the Ethyl ester is by far the most important and most popular one. But also other groups like Methyl-, Butyl-, Alkoxy- and Propylesters do have certain advantages.

Secondly the viscosity cannot be ignored. The range varies from liquid like water up to thixotropic gels. In general viscosities between 80 to 200 mPa*s (CB 2011, CB 2028, CB 2610) are popular for manual applications. There is one exception though, which is the very much faster bonding of elastomers. In this case, generally much thinner (10 to 30 mPa*s) products are used (CB 2006 and CB 2008) which react even faster and give a softer adhesive seam. In cases where you have to bridge small gaps or if you have to move or adjust products that are being bonded, viscosities in the range of about 700 to 2,000 mPa*s are very suitable (CB 2077, CB 2150). Gel products are used in order to bridge even bigger gaps or on porous materials (CB 2999). One has to point out though that industrial bonding applications with gaps over 0.2mm cannot be bridged with a Cyanoacrylate adhesive. (Please see chapter 3.5). Also the use of thixotropic products in serial production is possible, albeit with restrictions.

1.3 Strength Figures

Cyanoacrylate adhesives reach very high adhesion figures on most materials, also on smooth surfaces. This is the reason why the user does not really have to bother about shear- and tensile strength. As adhesive layers are normally hard and not elastic one should avoid a peeling load. This issue can be ignored when the bonded material itself eliminates most of the peeling loads (e.g. rubber, soft PVC). In most cases you will reach material failure by testing the strength figures. It is absolutely sufficient if one of the materials to be bonded has flexible properties. One of the recent developments can be seen in the Cyberbond "xtraflex" line which does not only give you partly flexible adhesive layers, but also a high temperature resistance.

1.4 Coloured and UV-light Detectable Cyanoacrylates

Due to the fact that ever increasing automation demands 100% supervision, products have been developed which can be optically recognised by UV-radiation, causing fluorescence. Cyberbond 1022 offers a reliable product for manufacturers of smartcards. Naturally, other products can be adapted too.

It is also possible to dye Cyanoacrylate adhesives in order to have a simple visual application control. The most popular colour is blue. On the contrary, there are shades of colours that make the seam of the two bonded adherents optically invisible. We offer Cyberbond 1701 as a skin-coloured cyanoacrylate that proved itself in medical equipment. Cyberbond offers individual adaptations.

1.5 The Systematic Series of Cyberbond Cyanoacrylate Adhesives

Information is given in the chapter "Cyberbond product programme".

- ▼ Powerdrop series
- ▼ Elastomer and plastic series
- ▼ Neomer series
- ▼ Xtraflex series
- ▼ Metal series
- ▼ Low Odour series
- ▼ Medical series

2 Base Monomers

This subject is very important because the monomer does influence the overall adhesion properties very much.

When manufacturing a Cyanoacrylate you need a cyano acid ester as a basic chemical. As one always makes a connection between the prefix "cyan..." (That is cyanhydric acid) it is to mention that cyano acid ester belongs to a different chemical compound and is not classed as harmful.

You can produce a Cyanoacrylate (the adhesive itself) by using a crack-and distillation procedure. The distillation process dictates the quality of the future product, because the level of purity has a deciding influence on the uniformity, the shelf-life and general quality of the product. However, costs play another important role.

Initially the distilled product is called 'Monomer'. This monomer bonds and is as thin as water. In a process one has to fix the requested characteristics such as viscosity, curing speed etc. To gain such a result, polymers (solids) and other chemicals are added to the monomer. As the monomer as such is a reactive adhesive, one has to choose the additives very carefully to avoid undesirable reactions – that is the curing of the whole adhesive charge.

The kind of cyanoacidester (ethyl-based, methyl-based etc) as a charge naturally determines the ester basis of the Cyanoacrylate as an adhesive. An important criteria to differentiate between the various alkaline is the chain length of the molecules that synthesize when curing.

2.1 Methylester (ME)

The first Cyanoacrylate Adhesive ever produced was a product based on the short chained Methylester $\text{CH}_2=\text{C}-\text{CN}-\text{COO}-\text{CH}_3$. Today the importance of this type is constantly decreasing, due to the ageing properties of modern plastics and elastomers not reaching the same performance as Ethyl esters. Methyl is mainly used for bonding metal to metal and fixing difficult to bond Duroplastics. A short term higher temperature and a good resistance against most chemicals are advantages of Methyl.

Due to the fact that metal to metal applications, where Methyl really perform very well, rarely take place in the world of Cyanoacrylate Adhesives (just relatively small pieces can be bonded). Ethyl esters are by far more important and give the user a better overall performance spectrum. For this reason Cyberbond has developed mainly Ethyl ester based products for applications bonding metal to plastic or metal to rubber.

2.2 Ethylester (AE – Cyberbond 2000 series)

The most commonly used Cyanoacrylate adhesive is based on ethyl ester $\text{CH}_2=\text{C}-\text{CN}-\text{COO}-\text{CH}_2\text{CH}_3$. These grades perform extremely well on plastics and elastomers and they achieve very good ageing and strength properties. Over the last few years ethyl have been constantly improved in their performance. Product features being realized by Cyberbond show improved temperature resistance and the possibility to create more and more flexible layers of adhesives during the polymerization process. We have created the xtraflex series (partly flexible and temperature-resistant up to 140°C) as well as the new xtra temp series (up to 180°C under certain conditions) which enjoy popularity in industry.

2.3 Butylester (BE – Cyberbond 7000 series)

Butyl Cyanoacrylate adhesives are well established in the market and are especially used in medicine.



Due to their structure of longer chains, butyl ester does not cure as aggressively and as fast as for example an ethylester or a Methylester. An exothermic reaction with the polymerization is hardly observed. This is the reason why it is preferred when bonding the skin of human beings and animals. Cyberbond offers these medical products only as raw material, not as a finished product for the end-user. Another advantage of the butyl ester is the bonding of sensitive parts without having cracks due to tension.

2.4 Alkoxyester (AOE – Cyberbond 5000 series)

These are very long-chained Cyanoacrylate adhesives and can be described as odourless. As a matter of fact the alkoxyester are very user friendly. However, one has to accept that the strength properties are not as good when compared to bonds using ethyl. Also, alkoxyester require longer setting times. Nevertheless, sufficient results in bonding can be firmly reached. $\text{CH}_2=\text{C-CN-COO-CH}_2\text{-CH}_2\text{-R}_1$ bzw. R_2
[$\text{R}_1 = \text{-O-C}_2\text{H}_5$ (Ethoxyester) bzw. $\text{R}_2 = \text{-O-CH}_3$ (Methoxyester)]

When reading the two formulas it becomes evident that alkoxyester is the genera for either ethoxyester or methoxyester. Their differences in bonding properties between the two groups are marginal. Cyberbond focuses exclusively on ethoxyester.

These adhesives also cover another important field of application. Cyanoacrylates tend to show a white coating, well known as blooming. Surplus monomer drop back to the adherents and leave white marks. One can even see fingerprints of the user on the mating parts. Cyberbond series 5000 eliminate these negative characteristics.

One should not forget to mention that for various reasons this range of products is more expensive than the standard ethyl ester. This is due to the purchasing costs for the raw ester and the low yield of manufacturing compared to ethyl ester.

3 Criteria for Optimal Bonding

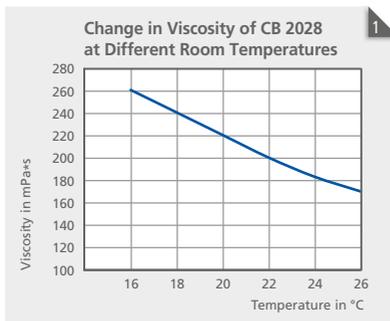
3.1 Humidity

Cyanoacrylate adhesives polymerize, respectively cure by the catalytic activity between the humidity in the air and the humidity of the adherents. The higher the relative humidity is (e.g. in a room) the faster the product cures. Best atmospheric conditions for good, reliable bonds are between 40 to 70 % relative humidity.

If humidity is too low (< 30%) setting time can become very slow; if humidity is too high (>80%) a so-called shock polymerization takes place. The latter provokes a certain shrinking process of the adhesive layer, which leads to less bond strength.

3.2 Temperature

Temperature influences the time of the chemical reaction very much. Generally it can be said that a 10°C hike in temperature results in twice as fast polymerization time. This is equally valid for Cyanoacrylate adhesives. The optimal room temperature for curing of these adhesives is between 20 and 24°C.



The change in viscosity at different temperatures has to be taken into account [Fig. 1]. The lower the room temperature gets, the higher the viscosity increases and vice versa. This can be of great importance when there are difficult applications. Cyberbond measures the viscosities and setting times at a room temperature of 20°C.

3.3 Influence of Different Materials

3.3.1 Metal / Metal Bonding

Due to the polarity of noble metals such as gold, platinum and silver these materials are difficult to bond with Cyanoacrylate adhesive. Generally, all non-noble metals can be bonded. Best results are achieved with less noble metal like iron or aluminium. We would like to point out that Cyanoacrylates are not suitable for bonding metal with metal compounds.

3.3.2 Plastic / Plastic Bonding

When bonding plastics the material itself and its polarity are important issues. Quite often certain fillers are mixed into the plastic which can cause adhesion problems. One item that is quite often overseen is the use of release agents in the production process. If a silicone based release agent is used then it cannot be bonded with Cyanoacrylate adhesive.

When bonding plastics which are known as difficult to bond such as, polyethylene or polypropylene, a pre-treatment can help to achieve good bonding properties. Suitable methods of pre-treatments are the use of Primer like Cyberbond 9056 or a Corona resp. plasma treatment. Enclosed please find a list of commonly used thermoplastic and duroplast.

Duroplast

Abbreviation	Chemical expression	Trade name	Bonding properties	Comments
EP	Epoxy resin		++-	
MF	Melamine-/ Melamine Phenol resin		+++	
PF	Phenolform-aldehyd resin		++-	
UF	urea-formaldehyde resin		+--	
UP	Unsaturated Polyester resin		+--	

+++ good, ++- satisfying, +-- bad, --- impossible

Thermoplastic

Abbreviation	Chemical expression	Trade name	Bonding properties	Comments
ABS	Acrylnitrilbutadienstyrol	Lustran, Novadur, Terluran	+ + -	
CA	Celluloseacetate	Cellolux	+ + -	
PA - PA 6 - PA 6.6 - PA 6.10, 6.12 - PA 11, PA 12	Polyamide	Ultramid, Vestamid, Zytel Perlon Nylon	+ + + + + + + + + + - -	
PBTP	Polybutylenterephthalat	Ultradur, Pocan, Vestodur	+ + -	
PC	Polycarbonate	Makrolon	+ + +	
PE	Polyethylene	Lupolen, Hostalen	- - -	with Primer CB 9056 + + +
PP	Polypropylene	Novolen	- - -	with Primer CB 9056 + + +
PMMA	Polymethylmethacrylat	Plexiglas, Altuglas	+ + -	Tension cracking
POM	Polyoxymethylen (Polyacetal)	Delrin, Hostaform	- - -	with Primer CB 9056 + - -
PPE (PPO)	Polyphenylenether	Noril	+ - -	
PS	Polystyrol (Polysterene)	as plastic: Vestyron foamed: Styrofoam, Depron	+ + + - - -	with CB 5000er Series + + -
PSU	Polysulfon		+ + -	Tension cracking
PTFE	Polytetrafluorethylen	Teflon	- - -	with Primer CB 9056 + - -
PVC - hard PVC - soft PVC	Polyvenylchloride	Hostalit, Vinidur	+ + - + + - + + -	
SAN	Styrolacrylnitril	Luran	+ + +	
TPU	Polyurethane	Vulkolan	+ + -	

+ + + good, + + - satisfying, + - - bad, - - - impossible

3.3.3 Elastomers / Elastomers Bonding

The bonding of elastomers normally is not difficult to achieve. But the formulation of the rubber has an enormous influence on setting time and strength values. In terms of setting time it has to be taken into consideration whether the mixture is turning to the polar respectively to the unpolar side. Rubbers based on polar elastomers are easier to be bonded than homopolar rubber. When bonding elastomers the basis of the raw material and the following factors are important if good ageing and strength properties are to be achieved:

- ▼ freshly cut rubber
- ▼ components of the rubber mixture such as
 - vulcanising process (sulphur or peroxide), accelerators (zinc oxides),
 - plasticisers (aliphatic hydrocarbons), ageing protectors (amines)

Experience has proved that good rubber-to-rubber or rubber-to-metal results are achieved by using Cyberbond. Even if a vulcanised joint still is the optimum in terms of strength, a bonded joint is easier and can be achieved without huge effort. There is no energy required and the application with Cyberbond can easily be fulfilled. To get a proper mitre bonding is today state of the art. But to reach good values a few procedures must be followed up. Important is a fresh cut of the two mating parts. Also the adhesive has to be applied to one side only. A slight and short pressing together leads to a thin adhesive layer. This is important to avoid too brittle a connection. If the rubber has to withstand certain temperatures, the formulation of these elastomers becomes important. To check this you should run an ageing test of the rubber joint. Very quickly you can recognise whether plasticisers permeate to the outside and if ageing protectors, waxes, agent releases or other additives will have a negative influence on this joint.

Elastomers

Abbreviation	Chemical expression	Trade name	Bonding properties	Comments
ACM	Polyacryl Caoutchouc	Hycar	+ + -	
ECO	Epichlorhydrin Caoutchouc	Hydrin, Herchlor	+ - -	
CIIR	Chlorine Butyl Caoutchouc	-	+ + +	
CR	Chloroprene Caoutchouc	Neoprene	+ + +	
CSM	Chlorsul-fonierter Caoutchouc	Hypalon, Baypren	+ + -	
EPDM	Ethylen-Propylen-Dien Caoutchouc	Vistalon, Buna AP	+ + +	
FPM	Fluor Caoutchouc	Viton	+ + -	
IIR	Isobutylen-Isopren Caoutchouc	Polysar-Butyl	+ + +	
NBR	Nitril Caoutchouc	Buna NB	+ - -	to be highlighted CB 2010 + + -
NR	Natur rubber	SMR	+ + +	
SBR	Styrolbutadien Caoutchouc	Buna SB	+ + +	
SI	Silicone Caoutchouc	Silopren	- - -	
TPE	Thermo-plastic Elastomers	Santopren	- - -	with Primer CB 9056 + - -

+ + + good, + + - satisfying, + - - bad, - - - impossible

3.3.4 Bonding of Different Materials

Naturally, you are not only able to bond materials like rubber, plastic, metal etc. to each other, but also in combination with each other. The most common application is the bonding of two different materials. Thus, both materials have to be taken into account carefully.

Not only plastics, elastomers or metals, that are industry's most common and important raw materials but also porous materials such as wood, leather, cork and ceramic can be fixed. In these cases we offer our special line of neomers; the viscosity resp. the thixotropy of the products can be very beneficial when bonding these types of materials.

3.4 Surface Conditions

3.4.1 Clean Surfaces

The surface condition of the mating parts has an enormous influence on the success of a bond. The roughness of the parts is not so important when using Cyanoacrylate adhesive, due to the fact that Cyanoacrylate adhesives reach very good strength properties, even on very smooth surfaces. More important than roughness, is that the surfaces to be bonded are clean. To achieve clean surfaces the following methods are most common:

- ▼ sand blast procedure
- ▼ chemical pre-treatment (etching)
- ▼ abrasive methods (sandpaper)
- ▼ steam (degrease by steam)
- ▼ washing
- ▼ cleaning (e.g. Cyberbond 9999 Cleaner)

It is impossible to say which method is most effective. This has to be decided from case to case.

3.4.2 The PH Value of a Surface

Especially in the field of Cyanoacrylate Adhesives one special item that is very important to consider is the PH-value. If the surface is acidic, the setting time slows down. On the other hand the set speed increases when the surface is alkaline. The latter can possibly lead to very short chains of polymers and to tension which can influence the bonding strength negatively. This is the reason why Cyanoacrylate Adhesive should not be recommended for glass bonding. The glass has a high PH-value. It can bond very quickly (shock polymerization) but this leads to shrinkage of the adhesive layer (after a few weeks) and the parts may fall apart again. Specially adapted and modified products could possibly offer positive solutions to such bonding problems.

3.4.3 Surface Tension

The surface tension of a substrate to be bonded reflects the ability of a liquid or adhesive to cover / wet the surface. The surface tension is measured in mN/m (Milli Newton/Metre (former dyn/cm)).

Please find below a table of the surface tension of some adhesives and other substrates:

Medium	mN/m
Cyanoacrylate	34,0
PTFE	19,1
PP	31,2
PE HD	35,1
PETP	41,3
PS	42,0
POM	42,1
PVC	45,2
PA 6	47,5
Metal	1.000 – 5.000

Non-polar parts such as PE, PP or PTFE let chemicals including Cyanoacrylates simply form droplets and avoid contact / spread with the surface. In contrast to this, polar surfaces allow a liquid to distribute itself easily.

Just like the mating parts, Cyanoacrylate and any other liquid for that matter have a surface tension. A Cyanoacrylate reaches a surface tension of approximately 34 mN/m. The mating parts to be bonded ideally should have a much higher mN/m value than the adhesive in order to guarantee a perfect coverage.

This shows why for instance, a PTFE (untreated) surface of a value of 19, 0 mN/n cannot be bonded with a Cyanoacrylate (34mN/m). A pre-treatment that enables bonding could be a primer such as our CB 9056 or by use of plasma treatment.

3.5 Thickness of Adhesive Layer

There are two reasons why the adhesive layer should be as thin as possible. First of all the setting time is determined by it. The thinner the adhesive layer is, then the faster polymerization will take place. But also the strength properties are better if the film layer remains thin. In terms of thick layers cohesion becomes more important than adhesion. The cohesion reflects the strength properties of the adhesive itself; the adhesion is the strength from the adhesive to the bonded surface. Concerning Cyanoacrylate adhesive the bond layer should not be greater than 0.2 mm. To bridge larger tolerances, higher viscosity or thixotropic products should be used. One may have to use a special accelerator like Cyberbond 9090 to help the product cure through the thicker layer.

The thickness of the adhesive layer depends on the viscosity of a product. If the mating parts fit together very well (measured in μ - tolerances) thinner products such as CB 2028 or CB 2008 guarantee best results. These very liquid Cyanoacrylate adhesives minimise the distance between the two parts in a way that 2-component products or higher viscosity grades could never achieve.

3.6 Dimensions of Mating Parts

Due to the very fast setting time Cyanoacrylate Adhesives can be successfully used if the bonded area is limited to a few square centimetres. The setting time can be adjusted by the producer, but only in a very limited range (fast, normal and slow curing). Recently we have been trying to use Cyanoacrylate adhesives for larger areas. It is very important that the mating parts are flat and fit accurately. Otherwise the relatively thin layer of adhesive can not bridge the gap.

3.7 The Use of the Additional Programme

(see also chapter VII)

In order to reach optimal polymerization results Cyberbond offers a range of additional products such as:

- ▼ **Cyberbond 9090 or 9096 Activator** which accelerates the polymerization of Cyanoacrylate Adhesives.
- ▼ **Cyberbond 9056 Primer** enables the bonding of unpolare materials such as Polyethylene (PE), Polypropylene (PP), Polyoxymethylene (POM) as well as modern Thermoplastic Elastomers (TPE) with the use of Cyberbond adhesives
- ▼ **Cyberbond 9060** dissolves and removes Cyanoacrylate Adhesives. CB 9060 is especially suitable for cleaning LINOP dosing equipment.
- ▼ **Cyberbond Conditioner Pen** accelerates, primes and cleans surfaces in one application and is applied via the very easy to use felt pen applicator.



4 Dosing of Cyanoacrylates

4.1 Manual Application (soft bottles and pin cap)

(see also chapter III 5)

Cyanoacrylate Adhesives – high or low viscosity – are relatively easy to apply. Especially when using the Cyberbond round LINOP bottles with an accurate dosing tip it is no problem at all. The bottle fits very well in the user's hand and due to the use of new materials it is extremely easy to squeeze. This easy-to-use soft bottle does not negatively influence the very good storage stability of Cyberbond products.



The new Pin Cap Nozzle is designed so precisely that the application of special low or medium viscosity adhesives is very accurate. In special cases the use of dosing tips might be necessary.

4.2 Automatic Application

(see also chapter VIII)

Cyberbond offers the LINOP dosing equipment programme in a modular system. Customers can choose from a wide range of dosing systems that will fully meet the requirements of their application. Cyberbond's programme starts with simple mobile applicators, semi-automatic units, right up to fully automatic dosing systems that are used in serial production processes. Before selecting appropriate valves etc we suggest users' contact Cyberbond for specialist advice. More information can be found on our website and in chapter LINOP of this book.



5 Economical Rationalisation by Use of Cyanoacrylates

At first glance Cyanoacrylate adhesives seem to be relatively expensive compared to other adhesive systems. We hope to make you aware that Cyanoacrylate adhesives quite often help to rationalise the production process. In comparison to most other adhesives, you have to remember that just a few drops are usually enough to reach satisfying strength properties. Compared to other adhesive 1gm of Cyanoacrylate adhesive contains approximately 80 drops.

- ▼ Cyanoacrylate adhesives are one component systems, an expensive mixing process is not required,
- ▼ Cyanoacrylate adhesives react within seconds without using any other energy such as heat, pressure etc.
- ▼ Cyanoacrylates are solvent-free which means (besides certain environmental aspects) that the glue is made up of 100% adhesive (solvent glues consist of up to 80% solvents that can not be used for bonding),
- ▼ Cyanoacrylates compared to adhesives of 2 components are very low in viscosity (liquid) and therefore very yielding,
- ▼ the fixed parts can be used immediately after bonding and stop over can be reduced
- ▼ different materials can be put together very quickly and accurately,
- ▼ fluorescent or coloured Cyanoacrylates can be optically distinguished,
- ▼ Cyanoacrylate adhesives can also be used as fixing aids in production and help to save time; final assembly by using Cyanoacrylates may even be the preferred method,
- ▼ by using a thixotropic Cyanoacrylate adhesive vertical applications can be accomplished successfully, because the adhesive does not run and stays exactly where it is put,
- ▼ Cyanoacrylates can be applied easily and economically with the help of dosing equipment,
- ▼ The use of dosing equipment as an option is relatively cheap and energy-efficient,
- ▼ Cyanoacrylate adhesives can also be used as repairing adhesives and can help to avoid rejects (for instance when using rubber moulded components),
- ▼ Cyanoacrylate Adhesives can be stored and transported easily, as they do not contain solvents and are not restricted and are classed as non-dangerous goods in terms of transportation.

6 Where to Use Cyanoacrylates

There is no doubt that Cyanoacrylate adhesives are especially suitable for the bonding of small pieces that fit well together. It is very difficult to say where exactly Cyanoacrylate adhesives are used as you will find them almost everywhere in industry. Electronics and the fine mechanical industries make use of them in serial production processes. They are also required as single-use products of medical equipment and for measuring and control devices. Cyanoacrylate adhesives are found in the plastic and rubber industries and are also used in the production of watches and various optical products.

The very good properties of Cyanoacrylate adhesives have also been recognised in other industries such as in metal and tool fabrication and as an electrode adhesive in locksmith's shops. They are suitable for bonding rubber profiles and O-rings or extremely stressed rubber/metal joints in the construction of machines and instruments as well as in the automobile, automobile-sub-supplier, ship and aero industry.

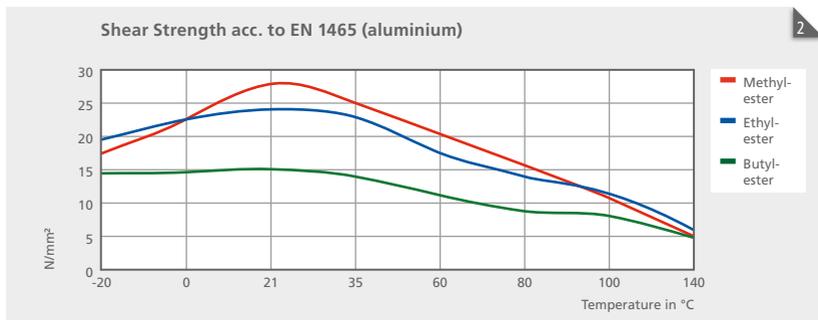
The variety of application fields for Cyanoacrylate adhesives is immense, being able to economically rationalize their use and having a wide range of products available are some of the reasons why Cyanoacrylate adhesives are irreplaceable as a means of joint technique. Nevertheless, any user should be made aware of their specific characteristics as neither Cyanoacrylate adhesives nor any other adhesive for that matter is simply an 'all-purpose glue'.

7 Properties of Cyanoacrylates

7.1 Influence of Temperature

In the cured condition Cyanoacrylate adhesives can be considered to be thermoplastics. Therefore an increase in temperature causes a decrease in strength. This process is reversible which means that the starting value is nearly regained after cooling down. However, in cool/cold conditions the adhesive becomes brittle.

The following diagram [Fig. 2] shows the strength values of aluminium strips bonded at increased temperatures acc. to EN 1465.



As you can see in this diagram the specific cyanoacrylate ester does have an influence on the different strength values gained at room temperature and also on the temperature loaded strengths. This test shows a short-term load on metal surfaces. Methyl-ester obviously shows best results. It is worthwhile mentioning here that in the field of metal-to-metal bonding Cyanoacrylates are not greatly used. The ethyl ester will perform better when combinations of materials are bonded. (Plastic to metal, rubber to metal etc)

Generally speaking Cyanoacrylates offer sufficient adhesion when bonding metal to metal at a temperature range of -30°C up to +100°C. A short term exceeding these temperatures will not do any harm. Maximum strength is reached at a working temperature of 15°C to 30°C. Reliable bonding results of plastic and elastomers are reached at a temperature range of -30°C to +70°C.

Bonding at temperatures outside this range can also be realized depending on the character of the original material. Please also see chapter 'special Cyanoacrylates' (Cyberbond xtraflex series) for more information.

7.2 Influence of Solvents

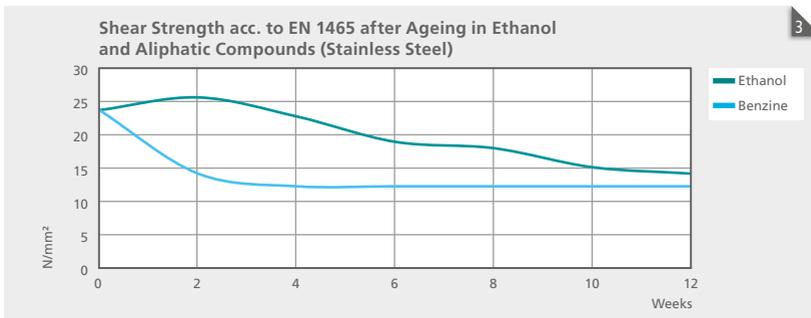
Chemical resistance means the stability of the adhesive film against liquid chemicals. We recommend a physical as well as a chemical point of view.

From the physical point of view the tension of the surface of the liquid plays an important role. Surface tension means the ability of a fluid to moisten a solid object (see chapter 3.4.3.). If the solvent has a low surface energy (measured in mN/m) the fluid runs over the whole surface and can infiltrate the adhesive layer. If the solvent surface tension is high the fluid contracts and does not spread very well. There is little chance of infiltration.

Medium	mN/m
n-Pentane	16,0
n-Hexane	18,4
Ethanol	22,5
Methanol	22,6
Acetone	23,3
Benzyl	28,9
Ethylenglycol	48,4
Glycerine	63,4
Water (20 °C)	72,7
Mercury (20 °C)	476,0

Cyanoacrylates are generally resistant to water. But a bonded joint can be infiltrated by water. Therefore Cyanoacrylates should not be recommended for bonding with permanent water influence. This is especially true when bonding metal as corrosion may appear and infiltrate the adhesive layer as compared to bonding plastics or rubber.

From a chemical point of view the aggressiveness of the solvent plays the key role. The concentrations and the characteristics of the polyacid and alkaline are the most important factors and have to be valued higher than the surface tension. The following table shows the strength values of Cyberbond 2028 on steel bonding [Fig. 3].



This is an attempt to group the most common solvents and to document the persistence of Cyanoacrylates towards the listed medium.

Solvent		
Type	Chemical expression	Resistance Cyanacrylat
Alcohol	Ethanol, Methanol, Isopropanol resp. Isopropyl Alcohol	+++
Ester (aromatic)	Ethylacetat (ethanoic acid)	---
Ketone (aromatic)	Acetone, Benzophenon	---
Aliphatic hydrocarbon (alkanes)	Petrol, Heptanes, Hexane,	++-
Aromatic hydrocarbons	Benzyl, Toluol, Xylol	++-
Halogenated hydrocarbon	Methylenchlorid, Chloroform, Chlorbenzol	---
Weak aqueous acid	Nitre, Muriatic acid,	+++
	Sulphuric acid, Phosphor acid	--- (concentrate acid)
Weak aqueous alkaline	sodium hydroxide solution,	+++
	caustic potash	--- (concentrate alkaline)

+++ good, ++ - satisfying, + - - bad, --- impossible

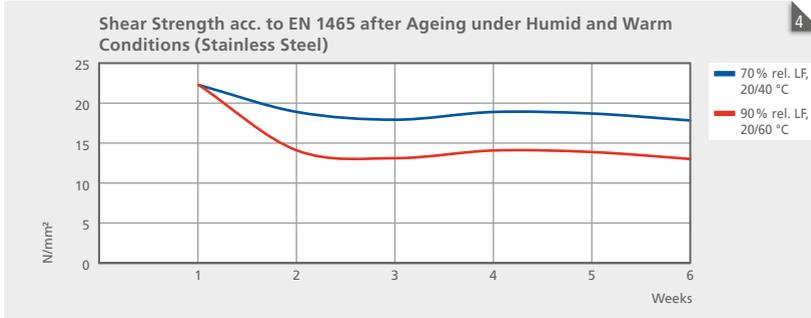
The solvents acetone and ethyl acetate damage any adhesive layer within a few weeks so it is absolutely not recommended to bond parts coming into contact with these solvents. Other solvents such as halogenated hydrocarbon or aromatic ester and ketones as well as concentrated acids and alkaline, corrode the polymers and lead to the bonded joint being dissolved, depending on the length of time of the influence. Long chained molecular and soft elastic Cyberbond products are less resistant against solvents due to their ingredients.

Careful working and a thin adhesive layer, as well as a possible protective paint or coating is paramount in avoiding joint infiltration by fluids. Also the influence of joint construction / design of a chemically stressed bonding should be considered over long-term observation.

7.3 Resistance after Storage under Warm and Humid Conditions

A decrease in strength and an infiltration of the polymer film can be caused by humidity and heat influence at the same time. Best conditions to improve the long-term stability are optimal surfaces; smooth mating parts, plain adhesive layers and the smallest of gaps. On high demands it is recommended to post-apply a protective paint.

Like many plastics, the Cyanoacrylate polymer can absorb small quantities of water after some time. But this does not cause a decrease in strength which can also be seen in the following table [Fig. 4]. The influence of construction / joint design and the surface of the material play a certain role under such a load.



7.4 Resistance after Storage under Difficult Climatic Conditions

The maximum stress limit depending on the material combination is additionally influenced when, next to humidity there are also temperature changes and in conjunction with this the different extension behaviours of the corresponding materials. In order to compensate these additional mechanical loads, the use of partly flexible products is very important. Please also see chapter “Special Cyanoacrylates (II 1)”.

7.5 Ageing

The ageing process of plastics and also of joints bonded with Cyberbond is influenced by many factors. In order to achieve reliable values ageing tests made in the laboratory have proved their worth. These ageing tests work like a time-lapse, which can be achieved by tempering at high temperature in order to see the chemical influence of additives resp. surface chemicals, as well as the physical tension decrease. But it has to be considered that the adhesive will not be affected because this would mean a stress test without giving any information on ageing behaviour.

8 How to Use Cyanoacrylates and Potential Dangers

8.1 Processing, Storage, Disposal of Cyanoacrylates

To use Cyberbond adhesives requires relatively small and plain mating parts. By slightly pressing these mating parts together, a thin adhesive film is achieved resulting in curing within a few seconds to minutes. Basic materials accelerate the polymerization so that an alteration could well be impossible. The polymerization process should not be interrupted; otherwise this would lead to weaker adhesion. Acidic material surfaces cannot only delay the curing but also prevent it.

Unopened bottles should be stored in a cool place such as a refrigerator; do not freeze the adhesive and do not store them together with anaerobic, UV-adhesives or two-component adhesives etc. as amines could escape from these and damage the Cyanoacrylate.

Once the bottle has been opened, always put the lid back on after use and keep at room temperature (approx 20°C). It is not advisable to put the adhesive back into the fridge as condensation formation may damage the adhesive. Over time (some weeks to months) the adhesive changes its viscosity. This could cause problems, but strengths should be sufficient. When in doubt dispose of the adhesive. When applying the adhesive, if it pulls strings then there will be problems. The adhesive should be thrown away and a fresh batch used. Hardened Cyanoacrylate is a thermoplastic and can be disposed of with plastic rubbish or in domestic waste. Liquid adhesives and bottles with liquid adhesives is classed as hazardous waste. Please check your regional regulations.

Experience over many years has shown there to be no health impairments expected when using Cyanoacrylate Adhesives. Due to the typical odour of the adhesive it is advisable to have good ventilation in the working area. For non-optimal working areas we recommend that adequate local exhaust ventilation be installed.

8.2 Potential Dangers of Cyanoacrylate Adhesives

8.2.1 Composition of Cyanoacrylates

Cyanoacrylates are fast setting, one component and solvent free adhesives. They are based on esters of Cyanoacetate. To get to a finished product mainly thickeners, respectively film forming agents (polymer methacrylics and acrylics) and stabilizers are added. The polymerization takes place due to humidity and/or by means of adding alkaline substances (activator).

8.2.2 Irritation of Mucosa Membranes

It is known that especially ethyl- and methylester based Cyanoacrylates are irritating to eyes and the respiratory system. The following symptoms may occur:

- ▾ Irritation of eyes, redness and more lachrymal fluid
- ▾ Irritation of nasal passages, mucous secretion and pruritus
- ▾ pharynx and bronchial passages are inflamed and irritated

The irritation of the mucosa membranes affects people in different ways similar to an allergy. We do not know of long-term health damage when using Cyberbond Cyanoacrylates in industry. Nevertheless, we recommend that sensitive people should not work with these products over a long period of time.

By using Cyanoacrylates with longer chains and based on alkoxyester – known as low odour Cyanoacrylates (CB 5000 series) – an irritation of the respiratory system can be avoided.

8.2.3 Unintentional Moistening of Eyes and Skin

Direct skin contact should be avoided in every case as Cyanoacrylate adhesives can bond skin within seconds. In most cases if skin contact arises, an intensive washing with warm soapy water and pumice is sufficient. One should treat hands with rich, oil-based creams.

If a drop of Cyanoacrylate gets into the eye, it will cure immediately due to the existing tear fluid. Due to the exothermic reaction heat will be created and the cornea will be affected. This shock polymerisation will provoke pain for a few minutes. The eye must be rinsed immediately with plenty of water and an anti-inflammatory ointment should be applied. After this seek medical advice. On the basis of our experience the cornea will rejuvenate within a few days. There will be no severe visual disturbances or eye damage.

8.2.4 Precautions

- ▾ use in well ventilated areas only
- ▾ install suitable exhaust systems in the workshop
- ▾ apply material economically and use a dosing system where appropriate (see LINOP programme)
- ▾ allow a consistent relative humidity of 50 to 65 %; with regards to lower figures the polymerization will be delayed and monomer adhesive fume will appear
- ▾ Adhesives have to be kept out of the reach of children
- ▾ accidental spills of bottles with Cyanoacrylates can be bound with low reacting, absorbent material (e.g. moist sand). Please be aware of exothermic reaction (temperatures of up to 150°C) and extreme vapour steams. Always work with breathing and face protection.

8.2.5 Explanation of the Safety Data Sheet for Cyanoacrylates (see also chapter II 8.2)

Generally the safety data sheet is the basis for judging the hazard potential of a product (see also explanations in chapter "What to consider when bonding"). But we would like to emphasise again that the marking of the different precaution sentences will probably change from the year 2011 on. For a transition period both precaution systems are going to be kept valid.

8.2.5.1 Label Classification of Ethyl esters

▼ Ethyl esters in packages > 125 ml

This information has to be printed on the label if the bottle (trading unit) is more than 125 ml.



Xi Irritant

R 36/37/38 Irritating to eyes, respiratory system and skin
 S 23.3 Do not breathe vapour
 S 24/25 Avoid contact with skin and eyes
 S 26 In case of contact with eyes rinse immediately with plenty of water and seek medical advice
 S 51 Use only in well ventilated areas
 Cyanoacrylate! Danger! Bonds skin and eyelids within seconds.
 Keep out of reach of children.

▼ Ethyl esters in packages < 125 ml

As Cyanoacrylates are quite often filled in packages of less than 125 ml and there is not enough space on the labels it is acceptable to shorten the precaution sentences as follows:



Xi Irritant

Cyanoacrylate! Danger! Bonds skin and eyelids within seconds.
 Keep out of reach of children.

8.2.5.2 Label Classification of Butyl- and Alkoxyester

These are longer chained and less aggressive Cyanoacrylates. The precaution sentence as follows is sufficient:

Cyanoacrylate! Danger! Bonds skin and eyelids within seconds.
 Keep out of reach of children.

B Special Cyanoacrylates

1 Cyberbond xtraflex series

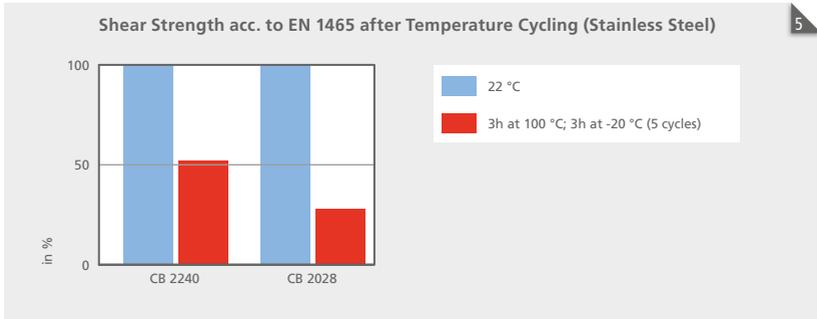
Partly flexible Cyanoacrylates

(CB 2240, CB 2241, CB 2242, CB 2243, CB 2245)

Continuous miniaturization (shrinking) of parts that have to be bonded, especially in the electronics industry, have led to much higher stress requirements (percentage wise in terms of surface area) in the adhesive bond layer. In the past Cyanoacrylate adhesives had been used in spite of their high dynamic strength figures of 22 to 25 N/mm² only as a mounting aid and the performance envelopment of these adhesives was never usually pushed to the maximum. Today we expect maximum strengths on small surfaces. However, one should not be tempted to abandon relevant laboratory tests.

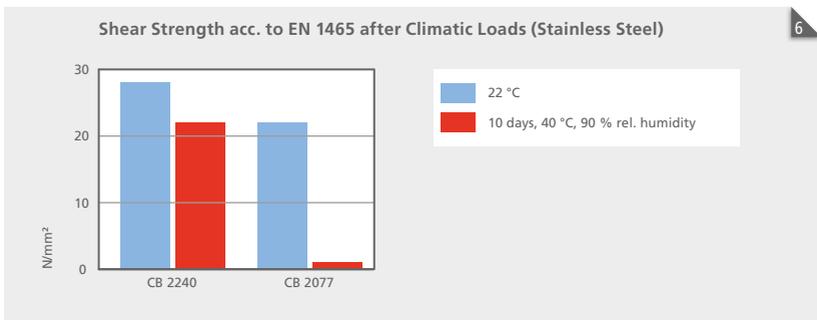
Over the past few years Cyberbond has developed the xtraflex series of partly flexible products that create good strength levels. These products are placed in between the rigid low viscosity Cyanoacrylates and the high viscosity, often thixotropic and slow curing products. The importance of these products is highlighted greatly in applications where the adhesive joint is exposed to varying temperatures, when humidity influences the bonding or if the two bonded materials have different thermal expansion. Cyberbond xtraflex Cyanoacrylates overcome the dynamical stress.

The application of metal to rubber has always been difficult. Part of the stress on the adhesive layer can be absorbed by the soft substrate of rubber. But due to different expansion coefficients of the mating parts, the adhesive film often becomes loose, including an adhesive layer with a thickness of 100μ. This subject is of even greater importance when only stiff / non-flexible material has to be bonded.



The diagram [Fig. 5] shows a lower decrease of strength after 5 cycles at 100 °C but at -20 °C for 3 hours the partly flexible Cyanoacrylate CB 2240 retains much more of its initial strength, approx 52 percent, whereas the standard ethyl ester based Cyanoacrylate (CB 2028) only retains 28 percent.

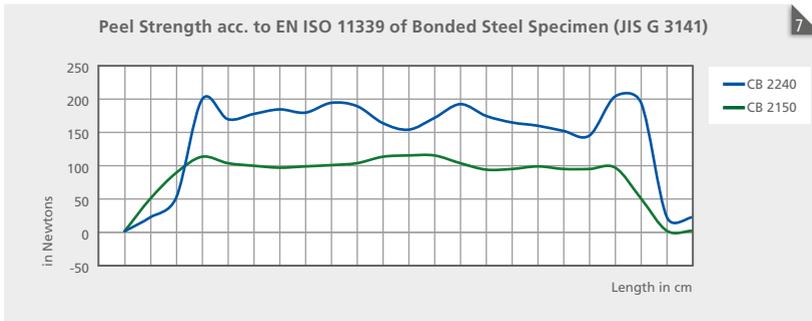
Stainless steel test pieces show after a full cure and climatic load a dramatic difference in the mechanical and chemical stress resistance [Fig. 6].



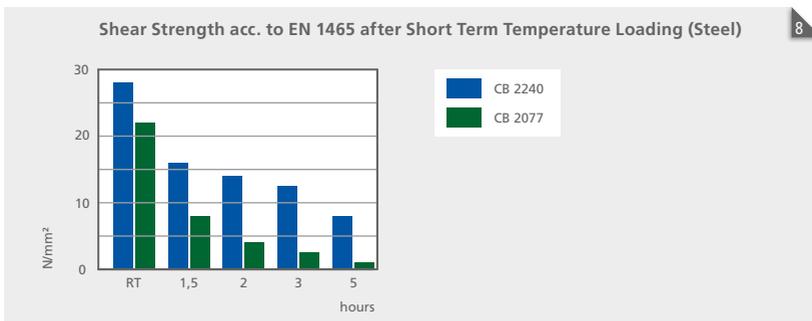
After a climatic load (10 days, 40°C, relative humidity 90%) CB 2240 shows a shear value of around 22 N/mm² and conclusively this strength was neither heavily influenced by adhesion or cohesion failure. This is different with standard products. After the climatic tests these standard adhesives did not show sufficient strength anymore. Stainless steel was used as the absence of surface oxidation (corrosion during the test procedure) gives a true reflection of adhesive bond performance.

Practical tests in the laboratory have proved these results again and again. It has been observed that the adhesive layer has resisted diffusion of humidity under harsh environmental conditions.

The difference in flexibility can also be clearly illustrated by a common peel test. The test was conducted on steel (material number 100.37) with an adhesive layer of an average thickness of 0.05mm. The diagram [Fig. 7] shows two modified products in comparison. Both products have the same viscosities to minimize the influence of the layer thickness. It shows that CB 2240 is superior to the standard CB 2150. One achieves double enhanced peel strengths.

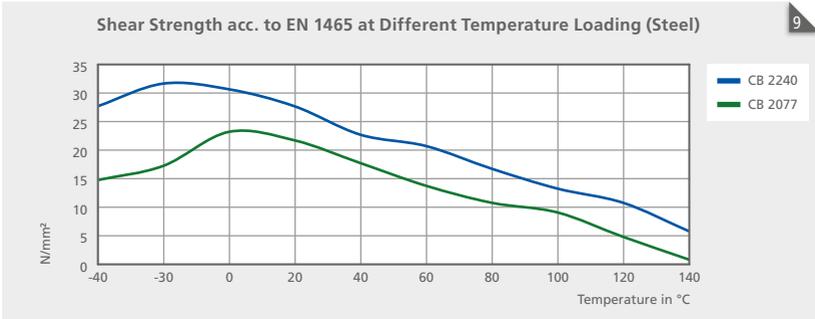


In practice a belt for example, is constructed from a reinforced fabric material and is jointed by a special overlap technique using a semi flexible Cyanoacrylate. Exhaustive tests have shown that a joint made in this way with Cyberbond adhesives can fulfil all the requirements of durability and temperature resistance.



In practice the user will notice that the set speeds of these modified products are not significantly slower than normal Cyanoacrylate adhesives. Nevertheless, all reactive adhesives based on Cyanoacrylate chemistry rely completely on the moisture content of their surroundings to determine their cure speed.

Another benefit of using Cyberbond xtraflex adhesives in industry is the gain in temperature resistance of these modified, partly flexible products. The short-term heat resistance in terms of shear strength is increased substantially. These products show better results in all temperature ranges [Fig. 9].



2 Neomer Technology by Cyberbond

Generally, Cyanoacrylate Adhesives bond many different materials relatively quickly, to each other and in many different combinations. One crucial criteria is the surface of the mating parts (see also chapter I 3.4). Without taking gaps and roughness into consideration at the moment, we want to contemplate porosity and pH-value of a surface and therefore, one should realise that acid surfaces slow the setting time down or actually stop the polymerization completely, while an alkaline surface accelerates the bonding process.

The Neomer Technology is linked to the subject 'acid surfaces'. Many different types of wood have an acid and porous surface. When applying Cyanoacrylates to these surfaces, the curing is delayed and in extreme cases the adhesive is soaked into the substrate and therefore leaving nothing to create a bond. By selecting a higher viscosity (thicker) adhesive product, this will at least overcome the soaking effect, so this particular issue will no longer be relevant. However, please remember that the setting times will be very slow. (Minutes).

Cyberbond offers with its Neomer Technology a further developed and strongly improved range of Cyanoacrylates. These product developments result in the following: the Cyanoacrylate contains an additive that neutralizes the acidity and enlarges the surface tension. The adhesive therefore cannot be soaked away anymore and the polymerization takes place much faster.

The base of these accelerated or so-called surface insensitive grades is not new and has been developed more than 20 years ago. Different chemical reactions have to be considered and transformed into the products. If a Cyanoacrylate Adhesive is accelerated in the afore-mentioned way, then the finished product has to be highly stabilized to ensure sufficient shelf life can be reached. But this higher stabilization slows down the setting time on common materials dramatically, respectively it prevents the polymerization completely.

With CB 2600 and CB 2610, Cyberbond offers two top products with the Neomer Technology that not only bond wood, leather, cardboard and even paper quickly, but also bond rubber and plastics very fast. The two products differ in their viscosity. CB 2600 is thin like water, while CB 2610 has a viscosity of 120 mPa*s that is easily processed. CB 2610 should be considered as the standard grade, but in the end the choice depends on what has to be bonded.

3 Cyberbond Cyanoacrylates in Medicine

3.1 Cyberbond in Single-use Medical Products

(see also chapter VI 7.3)

Cyanoacrylates are used to a great extent in medical instruments. Applications include; the bonding of needles into plastics, such as syringes. These products are tested before use for a medical purpose. However, it is thoroughly favourable if one can be assured that CA is not dangerous to human beings and animals. There are a large number of approval norms such as FDA (US Food and Drug Administration), USP (United States Pharmacopoeia) or ISO 10993 standard.

For Cyanoacrylates the approval norm USP class VI and ISO 10993 are mainly applicable. Cyberbond holds approvals for both classifications; recently we have concentrated on ISO 10993 as this is highly recommended at an international level and meets strict regulations. The norm ISO 10993 however, consists of a large number (20) of various tests. The most important aspect is the biological compatibility, which is the compatibility of an article on or inside a body.

Cyberbond holds approvals for the following:

▼ **ISO 10993-5: Test for in vitro cytotoxicity**

In an Agar diffusion test it is checked if Cyanoacrylates destroys a cell culture.

▼ **ISO 10993-10: Tests for irritation and delayed-type hypersensitivity**

Rabbits are injected intradermal. This means that the extracted Cyanoacrylate is injected via a substrate in the deep layers of the dermis to find out if – due to vascular dilation – there is an inflammable flush of the skin (erythma) or an accumulation of liquids (edema)

▼ **ISO 10993-11: Tests for systematic toxicity**

Mice are injected with the extracted Cyanoacrylates via a substrate intravenously and intraperitoneal (in the abdominal cavity). There must not be a biological reaction by the body.

▼ **USP Class VI: USP 25, NF 20: Biological Reactivity Tests in vivo**

This test is similar to 10993-10. For this mice and rabbits are injected intradermal. Besides this, the medium is implanted in the Para vertebral muscles of rabbits. No noticeable reactions should occur.

Cyberbond produces the following Cyanoacrylates certified by ISO 10993 for the medical equipment industry:

Cyanoacrylates in Medicine

ISO 10993-5: Test for Cytotoxicity	ISO 10993-10: Tests for Irritation and Sensitization	ISO 10993-11: Tests for Systemic Toxicity
CB 2003	CB 1603	CB 1603
CB 2004	CB 2000W	CB 2000W
CB 2028	CB 2008	CB 2008
CB 2075	CB 2011	CB 2011
CB 2040-05	CB 2028	CB 2028
CB 2241	CB 2077	CB 2077
CB 2241-05	CB 2800	CB 2800
CB 2243		
CB 5005		
CB 5241		
CB 5100 Black		
Apollo H-3		

3.2 Cyanoacrylates in Surgery

Special Cyanoacrylates are used in surgery to bond the skin of human beings or animals. Cyberbond offers highly pure butyl ester based Cyanoacrylates to respective companies that sell these particular products to special customers such as hospitals or surgeries.