ADHESIVE AND PROCESS INVOLVED IN ADHESION TECHNIQUE

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Abstract - Adhesive bonding combines the physical surfaces with the chemical force based on the bonds produced between the surfaces. When done properly, the claim is that the cost of the joint formed which offers the required joint efficiency, load capacity, strength, damage tolerance, etc beyond the potential benefits. Furthermore, advancement in development of automation in the ongoing industrial processes and replacement of the traditional adhesive used for the process considering the pros and cons this paper explores the requirement and replacement in the use of adhesive for bonding. Where the process could or should move to next level.

INTRODUCTION

The bonding of two different surfaces of same or different matters is a topic of great interest for research and development for both industrial and general perspective. These bonds could be chemical bonds, physical bonds, magnetic bonds and mechanical bonds according to the requirement of the product and its cycle. Recent the commonly used bonding is the chemical bond which involves the addition of the agent (adhesive) to the surfaces (adherent). According to the requirement of the system with the specified circumstances for fixation of the surfaces desired. The adhesive are classified as:

- One part system
- Two or more part systems

Adhesives are basically polymers chemically activated, charged to react within the presence, absence of the conditions for solidification to act successfully within the desired conditions (force, pressure, temperature, etc.). Adhesive bonding is a process of joining materials in which an adhesive (liquid or semi solid state material) is placed between the faying surfaces of the part (adherents) to be joined. Either heat or light or pressure or all are applied to get bonding. The detailed explanation on the steps followed to get an adhesive joint is given below.

Three essential steps required to follow to make an adhesive joint including:

- Preparation of the surfaces,
- Application of the adhesive on to the mating surfaces, and
- Assembly of the work pieces /parts
- Curing the joint.

1.1. Preparing the surface

The work piece surfaces are cleaned by chemical etching or mechanical abrasion. Grinding, filing, wire brushing, sanding and abrasive blasting are some of the mechanical cleaning methods. Next the prepared surfaces are tested by their affinity to be wetted by water. It is called water-break test. Smooth spread of water is an indication that the surface is chemically clean while the collection of droplets indicates the possibility of oil film in the surface.

1.2. Application of the adhesive to the surface

1.3. Adhesives are applied on to the work piece surface by hand brushing, spraying, roller casting, knife coating and dipping. They are also applied as sheet or tape type coating to the surface. The adhesive are either applied as one thick layer on one of the work piece surface, or as a thin layer on surfaces of both the work piece.

1.4. Assembly of work pieces

After the application of the adhesive, the work pieces are assembled and held together by means of clamps, tools, tack welds, or other fixtures. During the assembly process, sufficient care should be taken so that the open time of the adhesive is not exceeded, the parts are put together in the proper sequence, the bonding is performed under specified environmental conditions, and the parts are held together until cured.

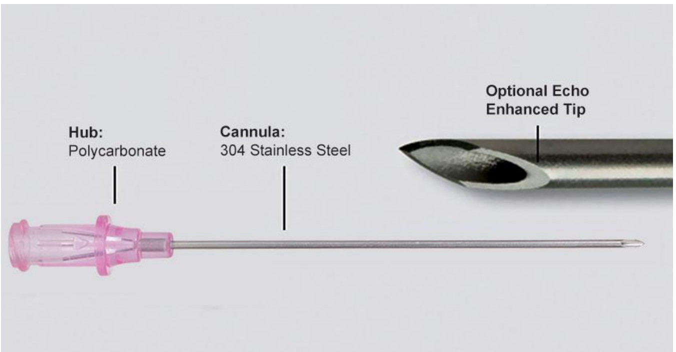
1.5. Curing the joint

Curing is the process during which an adhesive changes from a liquid state to solid. The curing of the adhesive is performed with pressure and either heat or addition of suitable catalyst. The pressure should always be uniformly distributed over the entire joint. The curing temperature, time and the pressure combinations for different adherents and adhesive combinations are given elsewhere.

Adhesives are broadly classified into two groups – structural adhesives and non-structural adhesives. Structural adhesives are having high load carrying capacity while the nonstructural adhesives are having low load carrying capacity. As the structural adhesives are most famous among the two, the same is discussed in the present section. Structural adhesives are generally classified into two groups – thermoplastic and thermosetting. The thermoplastic adhesives get soften at high temperatures. The most commonly used thermoplastic adhesives include polyamides, vinyls and non-vulcanizing neoprene rubber. The vinyls are especially very popular for structural applications. For example, polyvinyl acetate is used to form strong bonds with metals, glass and porous materials. The thermosetting adhesives usually do not get soften at high temperature. Once they harden, these adhesives cannot be remelted and a broken joint cannot be rebounded by heating. Thermosetting adhesives are mainly available in two variants – phenolic resin and the epoxy resin. Phenolic resins are the best bonding materials for waterproof plywood. Epoxy resins produce the joint with high strength, toughness, chemical inertness, and low shrinkage. These adhesives can be cured at room temperature. Other thermosetting adhesives include melamin-formaldehyde, polyurethanes, polysters, phenolic rubber, and neoprene rubbers.

The selection of the adhesive depends upon the standards and requirement in various industries like medical, glass ware, glass, furniture, optical industries, automobile, aeronautical, marine industries. This theoretical article is comprises the medical industry and the standards which comprises the use of adhesives are as ISO-10993, ISO-14971, ISO-13485.

This article is specialized for the medical equipment involved in the angiography as the standards are stated accordingly, introducer needle comprises of the assembly of metallic needle with the polymer hub



Traditionally from last decades thermoplastics adhesives are used for medical industries classified due to the curing method for solidification and bond formation as

- Heat cure
- Light cure(UV)

Advantages of using adhesives in the bonding procedure:

• Fast and cheap joining technique

• The adherents are not affected by heat

• Uniform stress distribution

• Possibility to join large structures

• Ability to join different materials

• Possibility to join very thin adherents

• Gas proof and liquid tight joints

• No crevice corrosion

• No contact corrosion

• Good damping properties

• High dynamic strength.

Applications of Adhesive Bonded Joints:

1. Bonding of metal to non-metals especially plastics is the major application of adhesive bonding.

2. Used as an alternative to riveting for aircraft structures.

3. Widely applicable in fastening of stiffeners to the aircraft skin and in assembling honeycomb structures in aircraft.

4. Using extensively in the fabrication of aircraft internal structures and providing the smooth surface for supersonic planes.

5. Useful in automobile industry for attaching brake lining to shoes, automatic transmission bands, and stiffeners.

6. Find applications in the fabrication of railway coaches, boats, refrigerators, storage tanks, and microwave reflectors for radar and space communications.

Table1: Shows properties of different adhesive

S.no.	Adhesive chemistry	Color	Viscosity cP	Relative fluorescence (in uncured state)	Fixture time, sec	Tack free time, sec	
					30mW/cm^2	30mW/cm^2	100mW/cm^2
1	Light cure acrylic	Transparent to hazy	100	Moderate	<5	20-30	5-10
2	UV cure acrylic	Transparent to hazy	6300	Moderate	<5	>60	20-30

3	Light cure acrylic	Transparent to hazy	8500	High	<5	5-10	<5
4	Light cure acrylic	Transparent to hazy	150	High	<5	>60	>60
5	Heat cure epoxy	Transparent yellow	5300	Superior	N/A	N/A	N/A
6	Heat cure epoxy	Off-white	8000	Superior	N/A	N/A	N/A
7	Heat cure epoxy	Light grey	25500	Superior	N/A	N/A	N/A
8	Light cure Cyanoacrylate	Translucent green	20	Moderate	<5	<5	<5
9	Light cure Cyanoacrylate	Translucent green	900	Moderate	<5	<5	<5

Table 2: Shear capacity of adhesive with different constituents

S. no.	Adhesive chemistry	Block shear capacity, psi							
		Acrylic	Epoxy *	Nylon *	PBT *	PC	PVC *	Aluminium *	Steel *
1	Light cure acrylic	240	720	650	600	620	380	1260	1480
2	UV cure acrylic	430	1020	630	600	630	790	1360	1700
3	Light cure acrylic	790	1120	610	730	1020	570	1600	1690
4	Light cure acrylic	1120	1130	490	800	3060	750	2150	2390
5	Heat cure epoxy	580	2240	620	1670	370	N/T	4160	4930
6	Heat cure epoxy	530	3380	760	1650	340	N/T	4570	5830
7	Heat cure epoxy	560	2450	820	1640	305	N/T	4580	6590
8	Light cure Cyanoacrylate	320	720	160	540	2200	260	1590	1460
9	Light cure Cyanoacrylate	320	470	240	690	2060	410	870	1480

Table 3: Physical properties of adhesive

S. no.	Adhesive chemistry	Cure through depth, 10s at 100mW/cm^2, inches	Tensile capacity, psi	Elong. To break, %	Modulus, psi	Hardness, shore D	% water absorption		Tg, C
							2 hr. boil	7 day RT	
1	Light cure acrylic	0.066	1440	134	20250	65	3.4	2.9	40
2	UV cure acrylic	0.071	3120	160	20750	60	3.2	2.6	35
3	Light cure acrylic	0.086	2610	140	31500	64	3.7	2.2	49
4	Light cure acrylic	0.082	2830	32	122750	67	5.9	8.8	82
5	Heat cure epoxy	35min@100 C 23min@125 C 16min@150 C	8970	3.0	345500	84	1.8	0.6	56
6	Heat cure epoxy	24min@100 C 23min@125 C 16min@150 C	8310	2.7	362000	86	2.4	0.7	89
7	Heat cure epoxy	25min@100 C 24min@125 C 17min@150 C	5540	1.1	566000	84	1.6	0.4	74
8	Light cure Cyanoacrylate	0.152	4720	2.2	250700	82	2.0	1.1	116
9	Light cure Cyanoacrylate	0.172	4840	2.2	262900	82	2.6	1.2	114

Table 4: Needle Pull capacity

Description		Capacity, lb								
		Hub Substance								
S. no.	Adhesive chemistry	ABS	ACRYLIC	PC	PE	PE*	PP	PP*	PS	PU
1	Light cure acrylic	37	35	36	7	24	4	19	43	23
2	UV cure acrylic	35	34	35	2	30	1	12	33	30

3	Light cure acrylic	40	40	42	12	31	7	22	48	23
4	Light cure acrylic	61	56	50	10	35	12	45	45	34
5	Heat cure epoxy	68	62	20	3	48	4	36	43	63
6	Heat cure epoxy	66	67	28	4	49	5	46	56	63
7	Heat cure epoxy	51	57	24	3	45	6	33	50	44
8	Light cure Cyanoacrylate	31	43	55	9	22	4	12	22	22
9	Light cure Cyanoacrylate	40	34	26	1	22	1	4	20	33

All the above tables are formed by the testing done by the 'DEKA' and the analyses are done in the manufacturing unit of the introducer needle in New Delhi, India. Where the parts are manufactured, assembled and examined by the quality checks.

CONCLUSION

The conclusion of the research done above is to compile the information from peer reviewed source of literature, although a sufficient amount of information is mentioned in FDA design control guidance for medical device manufacturer and also ISO standards. But experimental evaluation is must for any medical device as it is for protection of human subjects. This research concludes performance parameter of 'Introducer needle' intensioned for medical intension. The method of investigating the properties and definedation comprises the best in purpose and assortment of ingredients for manufacturing as well as assembly of medical device.

Adhesive benefits and considerations

ADHESIVE CHEMISTRY	BENEFITS	CONSIDERATIONS
Light-cure acrylic	• Fast cure—6 to 20 seconds under a high-intensity light source. • Wide range of physical properties available. • Low viscosity (100 cP) provides fast flow when applying to a preassembled needle and cannula. • Thermoset resins have good thermal and chemical resistance.	• Will not cure in shadowed areas. • Interface cure is inhibited by oxygen and can remain tacky if a high-intensity light source is not intensioned.

Light-cure Cyanoacrylate	• Fastest cure—3 to 6 seconds with a low-intensity light source. • Interface cure of <5 seconds with a low-intensity light source. • Cures rapidly in shadowed areas via cyanoacrylate cure mechanism. • Wicking viscosity available (20 cP) that provides the fastest flow when applied to a preassembled needle and cannula.	• Highest volumetric cost. • Maximum viscosity of 900 cP mandates applying to preassembled needle and cannula. • Blooming in shadowed areas can compromise the aesthetics of the device. • Lower relative fluorescence. • Thermoplastics have lower thermal and chemical resistance. • Not recommended for intension on glass.

S. no.	Heat cure adhesive	Light cure adhesive
1	High viscosity	Low viscosity
2	High shear capacity	Moderate shear capacity
3	Good thermal and chemical resistance	Good thermal and chemical resistance

Benefits of using UV curine in place of epoxy as adhesive are:

- Automation can be achievable for manufacturing system.
- The pull capacity of UV cure epoxy is better than epoxy.
- UV cure epoxy assemblies decrease the chances of infection.
- Cost of bonding reduces by 20%.

References

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