

Recent progress of RP resins by CMET Inc.

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Abstract

New liquid photo curable resins, epoxy based TSR-821 and 2081, and imide based 2090X, for rapid prototyping by UV Laser are developed. Hardened TSR-821 shows high impact strength with high flexural modulus almost same as properties ABS. This is very useful not only for verification model but also for mechanical testing model. Cured TSR-2081 is very tough having milky white color, useful for injection molding die to give more than 200 ABS molded products. TSR-2090X shows a particular stability for water, and useful for mass production part. This is the first example that the fabricated model by the stereolithography is used for a commercial instrument. Developing of a new resin enables a rapid prototyping system to a rapid production system in the near future.

1. Introduction

The stereolithography has become very

powerful tool for manufacturing. The fundamental technology of the stereolithography consists of four elements; hardware, software, photo-curable resin and know-how to use, whereas they are based on the key technologies for the fabricating model, all of them photo-curable resin becomes most important item for the stereolithography, because the customer recognizes that the resin has a key factor for their research and development. We have been making a lot of efforts on developing a high performance resin with high functionality.

2. Short history of RP resins

Table -1 summarizes a short history of the stereolithography resins mainly used for a verification model. At the starting generation, the customer satisfied with visualization of 3D CAD model without accuracy. At the 1st generation the customer desired the accuracy in the 3D object. In those days, only CMET's SOUP

system was satisfied with the accuracy because its materials were only based on epoxy materials. All of the manufactures of the resin understood that the epoxy based resin is the most suitable for the stereolithography. In the 2nd generation, stability for humidity was a serious matter to get better model. We have got a great

successful by HS-680 resin for its superiority against humidity. The current period is considered to be the 3rd generation, durable resin becomes very popular in the market. The customers always expect more advanced, high performance resins in order to realize their ideas.

Table-1. The short history of the stereolithography resins

Year	-1993	1994	1998	2001-	2002-
Generation	Starting Generation	1 st Generation	2 nd Generation	3 rd Generation	4 th Generation
Base Resin	UA / EP	EP	EP	EP	EP
Item	Model	Accuracy	Humidity	Durability	ABS
CIBA vantico	XB-5081-1	SL-5180	SL-5510	SL-7540	SL-7560
DSM-SOMOS	SOMOS-3100		SOMOS-7100	SOMOS-9100	SOMOS 11100
3DS (RPC)				AccuDur100	
JSR	SCR-310		SCR-701	SCR-710 SCR-735	(SCR-735)
Asahi-Denka	HS-661 (EP)	HS-673S	HS-680	HS-681	HS-690
Teijin Seiki CMET		TSR-800	TSR-820	TSR-1938N TSR-821	

We have already developed some new functional resins with high performance and functionality, such as heat-stability, large impact strength, tensile strength, elongation at break and etc. in order to satisfy the customer needs.

3. CMET new resins

3.1 A new durable resin from PP to ABS (TSR-821)

For a long time stereolithography model had been believed to be brittle and easy to

break because of its poor mechanical properties. The model is required to be tough and flexible for the usage of functional and/or mechanical testing. A vantico SL-7540 was highly accepted by its flexibility and durability. However the resin has a modulus of 1.1-1.4 GPa corresponding to that of polypropylene (PP), the thin wall or layer is very weak and easy to veng by its weight. We have developed a very stable resin named TSR-821 having ABS level modulus of 2.2 GPa, and shows almost same properties as ABS resin

except its heat distortion temperature. The resin is based on epoxy materials comparing with oxetane, useful for the functional testing model. TSR-821 shows flexibility of polypropylene (PP) with high flexural modulus of ABS. The mechanical properties are listed in Table-2. Figure-1 shows typical example models made by TSR-821 resin. Figure-2 shows the stability at high humidity of 80% at room temperature. Self-tapping test was done as following conditions;

- a. Tapping screw: Nominal diameter size is JIS M4 (depth = 20 mm, pitch = 1.5)
- b. Boss shape: Height = 25 mm, external diameter = 8 mm
- c. Testing trial: 5 times

TSR-821 shows a perfect result for self-tapping test. It shows enough durability for assembling equipments or sets



Figure-1. Typical examples of TSR-821.

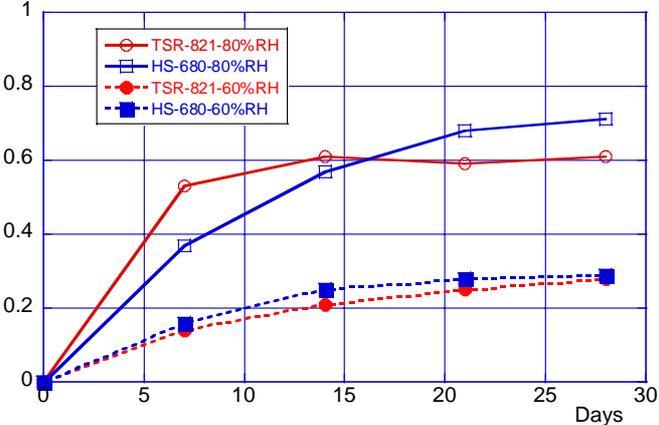


Figure-2. Dimensional stability of TSR-821 with HS-680 at 80%RH and 60%RH of room temperature

Table-2 Self-tapping test result for TSR-821 and HS-680.

Resin	Prepared hole diameter (ratio to tapping screw)		
	3.4 mm (85%)	3.6 mm (90%)	3.8 mm (95%)
TSR-821	5/5	5/5	5/5
HS-680	0/5	0/5	4/5

3.2 A imide based water resist resin (TSR-2090X)

We have developed a very unique resin based on imide acrylate materials. The new resin is useful for mass production part by stereolithography. Figure-3a and 3b show change in properties of cured TSR-2090X resin under water solutions (water, HCl, NaClO). The cured resin showed particular stability under each

condition. HITACHI Ltd., commercialized a very smart water analyzer using this imide material (see Figure-4). The water analyzer is reduced to 1/120 volume size, and also reduced the price to 1/4. This is the first rapid manufacturing example of by stereolithography technique. The new material brings an innovative product and technology.

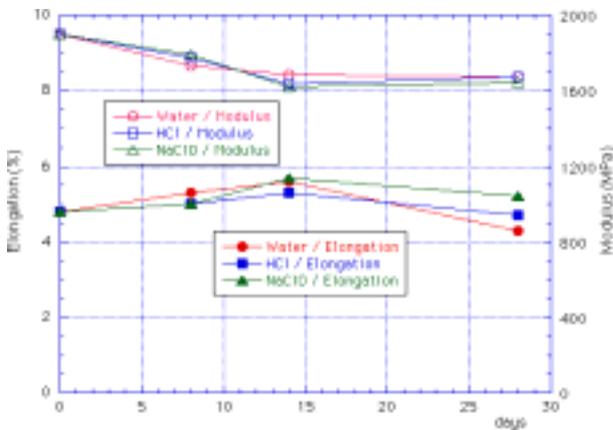


Figure-3a

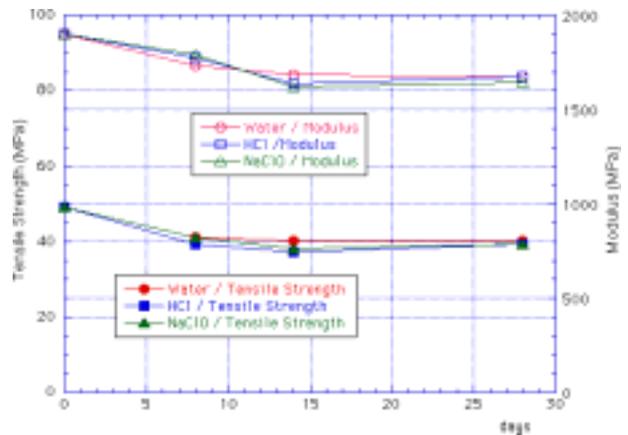


Figure-3b

Figure-3a Change in elongation and tensile modulus under each water solution.

Figure-3b Change in tensile strength and modulus under each water solution.

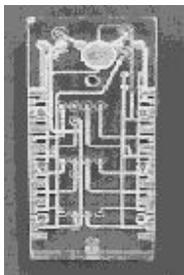


Figure-4

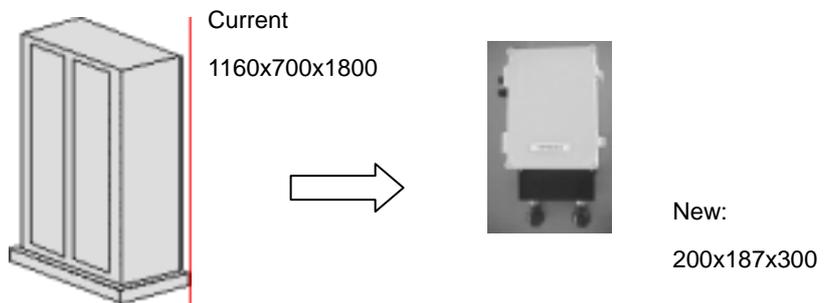


Figure-5

Figure-4 Manifold by stereolithography for commercial part using TSR-2090X.

Figure-5 Comparison of new type with current model.

3.3 A resin for injection molding die by stereolithography (TSR-2081)

TSR-2081 is a photo curable stereolithography resin based on epoxy materials containing inorganic fillers, designed for injection molding die. Cured TSR-2081 die shows very sharp edge and smooth surface, suitable for a trial injection molding die. It gives more than 200 molded products of ABS or PP (see Figure-6).



Figure-6. Injection molding die of TSR-2081 and its injected ABS product.

Table-3. Characteristics of TSR-821, 2081 and 2090X

Items	TSR-821	TSR-2081	TSR-2090X
Base resin	Epoxy	Epoxy	Imide
Viscosity (mPa.s)	380	3,000-4,000	300
Specific gravity	1.12	1.55	1.14
Tensile strength (MPa)	49	88	61
Elongation (%)	13-15	2	4.4
Tensile modulus (GPa)	1.8	7.8	2.4
Flexural strength (MPa)	70	153	81
Flexural modulus (GPa)	2.2	10.4	2.6
Impact strength (kJ/m ²)	4.8	1.5	-
HDT (°C)/1.82MPa	52-54	120	80 (Tg)

4. Summary

The new liquid photo resins, TSR-821, 2081, and 2090X, for stereolithography are developed. TSR-821 shows high impact strength with high flexural modulus, almost same properties as ABS. This resin is very useful not only for verification model but also for mechanical testing. TSR-2090X shows a particular stability for

water, and useful for rapid manufacturing. This is the first example that the fabricated model by the stereolithography is used for the commercial instrument. Cured TSR-2081 is very tough with milky white color, useful for the injection molding die to give more than 200 ABS injected product. The developing of a new resin will enhance the rapid prototyping to rapid production system in the near future.

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