Preparation and testing of herbal adamantine glue as described in *Brhatsamhita*

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*Brhatsamhita* of Varaha-Mihira (5-6th century AD) describes the materials and methods of cementing material in chapter Vajralepa. This chapter describes three different ways of adamantine glue preparations using either metal alloys or animal matters using herbal components. Although detailed information about the procedure and composition of adamantine glue from metal alloys or animal matters is given, no such detailed information is available regarding preparation of herbal adamantine glue. In this study, an attempt has been made to get the optimum composition and efficient procedure for preparation of herbal glue. The methodology suggested is found to give maximum bond strength of 97 KPa. The adamantine glue is ecofriendly and hygienic. The study may provide useful insight into the chemistry of green cement. There were ample uses of glue in the temple architecture of that period, the remains of which bear testimony to the strength of these cements.

Key words: *Brhatsamhita*, Varaha-Mihira, Adamantine glue, Green cement, Herbal glue

Scientist all over the world are making efforts to develop novel synthetic methods, reaction conditions, analytical tools, catalysts and processes under the new paradigm of green chemistry. Green chemistry is an innovative use of feed stock reagents, solvents, products or byproducts that have potential or proven hazards to the environment and public health. Thus, green chemistry is a fundamental and important tool in accomplishing pollution prevention by using chemistry in benign way. This modern approach clearly reflects in traditional Indian science and philosophy, such as scripture *Brhatsamhita* compiled by Varahmihir in 325 BC. Varahmihir is one of the greatest scientists of ancient India, who has contributed in as many as 108 disciplines.

One of the disciplines in *Brhatsamhita* is adamantine glue called Vajralepa. *Brhatsamhita* describes several preparations of Vajralepa, which means coatings as strong as thunderbolt. The subject of preparation of adamantine glue is closely connected with that of construction of temples, mansions, etc. as it was very essential for fixing idols, and in constructing walls when cement and other modern materials were unknown. Even now, the glue known as Astabandha is prepared in temple premises for fixing images of God. The ancient scripture on engineering and technology refers three main formulations of adamantine glue, i.e. using metals and alloys, animal matters, and herbal.

**Adamantine glue using metal:**

The cement, Vajra-sanghata, is to be compounded of 8 parts of lead, 2 parts of bell metal and 1 part of brass, melted and poured hot. It is stated that when this type of cement is applied to temple, etc. they last for around thousand years. Vajra-sanghata means, composition as hard as thunderbolt.

**Adamantine glue using animal matter:**

This type of glue is called as Vajratala, which is constituted by horns of cows, buffaloes and goats, hair of donkeys, buffalo-hide, cowhide, neem fruits, apples and myrrh. This mixture is boiled and reduced to eighth of its original volume.
Adamantine glue using herbal material:
The process for preparation of Vajralepa consists of making a concentrated aqueous extract of finely ground fruits, seeds, flowers and barks of plants rich in gummy and resinous substances by boiling and reducing the decoction to one eighth of original volume. This is then mixed up with naturally occurring resins and resinous substances and made into paste. The paste is heated and applied to walls of temples and houses. This cement is believed to cement things on which it is applied lasts for thousand years. In some preparations of Vajralepa, addition of mercury has also been recommended.

Methodology
Another reference of herbal adamantine glue is mentioned in Shloka 3 and 4. The glue was used in construction of temples, mansions, windows, walls and wells, as well as in fixing Siva’s emblems and idols of Gods.

The details of the contents of the herbal adamantine glue are depicted in shloka 3 but the optimum proportion is not mentioned. These two shlokas are explored in detail in this paper. Efforts are made to optimize the composition of the glue making use of the components given in shloka 3.

Composition, chemical constituents and biological activities of the raw materials have been discussed.

Amlaka (Emblica officinalis Gaerth.)
The chemical constituents of Amlaka are gallic acid, tannic acid, resin, sugar, albumin, cellulose and minerals, mainly calcium. Since it contains resinous material and calcium, it contributes to strength of the glue.

Bilva (Aegle marmelos Correa ex Roxb.)
Bilva is found all over India. The fruit contains 4.6% sugars, 9% tannin in the pulp and 20% in the rind. The seeds yield bitter fatty oil (11.9%), the gummy mucous substance surrounding seeds serves as good adhesive. It is more abundant in young fruits. When mixed with lime, it is utilized as cement and the mixture sets firmly and rapidly.

Kapittha (Feronia limonia Swingle)
The tree is found all over India. Pulp contains a large quantity of lime and iron therefore when used in cementing material imparts strength.

Madanfal (Randia spinosa Poir)
Madanfal trees get ripe in cold season. Owing to high tannin content, the fruits are highly astringent. The fruits extract exhibit excellent insecticidal, and insect repellent properties. The fruits are used as colour intensifier in calico printing.

Madhuka (Cynometra ramijora Linn.)
Madhuka flowers are rich sources of sugar and contain appreciable amount of calcium. It also contains Betaine and salts of maleic, succinic acid and essential oil.

Tinduka (Diospyros paniculata Durt.)
Tinduka is used as fish poison. It mainly conatin pectin (50%), tannin (15%), hexacosane, hexacosanol, monohydroxyl ketone, lupeol, and sallic acid. Pectin shows astringency, which is helpful for glue.

Neemba (Azadirachta Indica A. Juss.)
It is common all over India. It is reputed to posses anthelmintic and insecticidal properties.

Manjista (Rubia cordifolia Linn.)
Its root contains resinous matter, gum, colouring matter, and salts of lime. These properties of Manjista makes it vital constituent of adamantine glue.

Negada (Cathartium parviforum Lamm.)
It has medicinal properties. The fruits are sweet, and also called as Shikari meva.

Guggulu (Commiphora mukul Engl)
The gum resin is obtained by incision in the bark. Each plant yields about 1.5-2 lb of the product, which is collected in cold seasons. The resin contains 4.65% foreign matter, and 1.45% aromatic essential oils besides gum and resin.

Kapithaparni (Boswellia serrata Roxb.)
It is a gum resin known as Indian olibanum and used as incense. The oil is used for paint making, which dries within 24 hrs. Varnishes prepared with one part rosin and 1-2 parts turpentine oil, when applied to wood, dry slowly to a clear bright hard coat.

Laksha (Cateria lacca)
Laksha (Lac) is the excreta of the insects. Lac is found to be the major component contributing to the strength of the materials. It is resinous protective exudation of tiny insect parasitic on certain trees cultivated as a source of scarlet dye, and hard resin.
is subsidiary cash crop in many parts of India. Eighty per cent of world production of Lac comes from India.

Shellac (purified lac) is employed in admixture with resin, barytes, kaolin, pigments, etc. in preparation of sealing wax. Shellac reacts with vegetable oil fatty acid, and glycerin is used as a base for varnishes, which on baking yield pliable waterproof films on cloth, and soft films on metals and paper dish. Hydrolyzed shellac yields plastic compositions suitable for steam-jointing, bottle lopping and cork sealing.

**Rasa (Commiphora roxburghii Engl.)**

It contains resin-myrrh (27-50%) and gum (30-60%). The constituents like calcium phosphate, and calcium carbonate of Rasa gives strength when used in cementing material.

**Sarjarasa (Valeria indica Linn.)**

The bark contains tannic principles. It is a natural resin contributing to the strength of the adamantine glue. It is resin from tree sal, which is a large sub-deciduous tree. Under average conditions a sal tree has height of 18-30 m and a girth of 1.8-2.1 m. On tapping, the sal tree yields an oleoresin known as sal dammar or Bengal dammar. The resin is rough, stalactite, brittle, pieces 16-25 cu cm in size, pale creamy yellow in colour, nearly opaque, and having a faint resinous-balsamic odour.

Since, shloka 3 and 4 do not give any clear methods of preparation of glue, three methods tried are:

All the materials are taken in equal proportion by weight. *Manjistha*, *Madanfal*, *Nagbala*, and *Madhika* are soaked in water for overnight before mixing with other materials. The mixture is ground into fine paste. The glue thus obtained is somewhat sticky but on drying it does not show any binding property.

In the second method, equal proportion of aqueous extract (1:8) of all the materials are taken. Each material is added one by one successively in decoction. The product thus obtained does not show any binding property.

In the third attempt, the decoction of all the materials except resinous material (group B in Table 1) is carried in the ratio 1:4. The resinous materials are added to the mixture at the end. The product thus obtained has non-measurable binding property.

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<tr>
<th>Table 1—Detail of raw materials</th>
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From the above three experiments, it is observed that the third approach could yield good result with the modifications in composition. It was decided to change the composition of resins (group B in Table 1) keeping the non-resinous materials (Table 1, Group A), in equal proportions. The efficient process of preparation of Vajralepa consisted of following steps:

The raw materials (Table 1) are sun dried. Dried materials are ground, uniform mixing of materials result in a product of uniform particle size. Dried raw materials are ground. Care was taken while grinding resinous materials like lac, hirabol, and ral. The ground raw material was then screened using 60-80 meshes. The finely powdered raw material except resinous material is taken in a stainless steel container and digested with raw material in water (1:3). The mixture is boiled under constant stirring to get uniform paste and concentrated extract of the finely ground fruits, leaves and bark of the plants. The naturally occurring resins, and resinous material except lac are mixed with the hot paste obtained. The paste is once again heated to make the resin to go into the mixture. *Lac* is heated separately, and the molten *lac* is mixed with the hot paste. The final mixture, the adamantine glue is ready for application.

**Results and discussion**

Using the mentioned procedure different formulations of adamantine glue were prepared and
Table 2—Detail of compositions

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<th>Trail No</th>
<th>Composition</th>
<th>Strength (N/m²)</th>
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<tr>
<td>1</td>
<td>A and B in equal weight proportion</td>
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<tr>
<td>2</td>
<td>A: 2B</td>
<td>21767.39</td>
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<tr>
<td>3</td>
<td>A: 3B</td>
<td>39598.76</td>
</tr>
<tr>
<td>4</td>
<td>A: 4B</td>
<td>31324.00</td>
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Fig. 1 Strength v/s compositions of adamantine glue analyzed at Geotech Services, Nagpur (ISO 9001) on Universal Testing Machine. Varied proportion of resinous material was to study its effect on the strength of glue. Different compositions used and their strength has been presented (Table 2). Equal proportion of materials (Table 1, Group A) was taken; to improve the strength, the proportion of resinous material (Table 1, Group B) varied from 2 to 4 times, keeping rest constant. Variation of strength with change of composition has been shown (Fig.1). Maximum strength was obtained for the last composition. In the composition, resinous materials (A) was taken three times the non-resinous material (B). To find the key resinous component in glue composition, lac was taken three times than other resinous material, which was taken in equal proportion and three times that of rest non resinous material, i.e. lac was taken nine times than that of rest non resinous material. The strength of the adamantine glue thus prepared was found to be around 10 KPa.

Conclusion

The procedure explained in the paper for the preparation of herbal adamantine glue, as mentioned in Brhatamrta was found to be highly efficient. The higher proportion of resinous material maximizes the strength. Among the resinous material, lac was found to play a key component role; higher percentage of lac in the composition led to higher the strength of the glue.

References