International Journal of Eurasia Social Sciences
Vol: 10, Issue: 36, pp. (446-457).

Research Article

Received: 28.01.2019 *Accepted: 24.06.2019*

INSTRUMENT CLASSIFICATION ACCORDING TO RAW MATERIALS: EXAMPLIFICATION ON WIND INSTRUMENTS

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ABSTRACT

In this study, the family of wind instruments has been defined and the instruments included in this family been explained. The raw materials that are used in the production of wind instruments firstly classified according to their sources, and then chemical and physical features which make them different from the others are explained. The raw materials which are used in those instruments have been examined and classified according to their sources, chemical features, structures, and similarities. It has been seen that the raw materials which can be grouped as organics, inorganics according to their sources and composite which is made of using atleast two different kind of any material. Then those classes also allocated as the animal, herbal and synthetic under the organics; metal and nonmetal minerals under the inorganics and also the composites are separated as resinous and non-resinous structures. Although there are different types of wind instruments with each different raw material, these are compared with examples of wind instruments which produced via 3D printers. In this study, all these results and the classifications have been tabulated.

Keywords: Wind instruments, raw material, classification, carbon fiber, 3D print

INTRODUCTION

The material used for production of an instrument is one of the most crucial factors in terms of affecting the process, the techniques and technologies of the production of the instrument (Zoran, 2011). It is as well quite necessary to meet the various aims of usage and demands, since it affects the tone of the instrument and changes the chemistry of the object fully (Gibson, 2016; Fletcher, 2012; Toff, 1996). As in all other instruments, the importance of the role of the winds in classical western music, in terms of reflecting the period characteristics of each winds, the period characteristics of the work performed and the interpretation of the performer; the importance of the tone of these instruments is a stubborn fact (Hosmer, 1964; Bate, 1969). Wind instruments have been with us for over 30 thousand years; they were important during the Stone Age and still a very essential part of Today's World Music (Mayer, 2010; Toff, 1996; Bate, 1969; Dickens, 2007).

Wind Instruments

All instruments which use an air current as the primary vibrational source thorough a tubular construction are called wind instruments (Baines, 1991). In today's orchestras, wind instruments are divided into two major groups such as brasses and woodwinds. There are saxophones, tubas, horns, trombones and trumpets in the brass. And the woodwind family which generally are made of wooden that includes instruments such as oboe, bassoon, clarinet and flute[1] (Baines, 1991; Enrico et al., 2019; Dickens, 2007).

Various Raw Materials Used In Making Wind Instruments

The raw materials used in the production of wind instruments are divided into two basic groups qua organic and inorganic according to their sources[2] (Atkins and Jones, 1998).

Organic

It is characterized by a variety of different chemical compounds, which are naturally occurring or which have special carbon-hydrogen bonds in their structure. They are named organic materials because it has been considered[3] that they form through bio-chemical synthesis only by living beings (Atkins and Jones, 1998; Merriam-Webster Dictionary, 2019; TDK, 2019; Altıntaş, 2013; Aras and Tunalı, 1982; Saçak, 2006).

Organic materials can be studied within three categories according to their origins, which are animal, herbal and synthetic.

[1]Even though the flute is made of metal, it is classified as wood-wind instrument because of its historical development and sound group in the orchestra

[2] The raw materials which are used for production of wind materials may be chemical. According to their sources, they are divided into two main classes: Organic and Inorganic. But some materials, such as bone, are partially inorganic and chemical, if considered according to their origin, they are organic. Thus, 'according to the sources' title is seen more appropriate for classification (Topaloğlu et al., 2017).

[3] Although some organic materials having no living sources have been invented, they are still classified in the same way.

Animal Origin Organic Materials

Any animal origin raw material that have been used in the making of a wind instrument can be categorized under this title. Some of them are: bone, ivory and horn.

Bone instruments are the oldest instruments and the oldest wind instruments having reached to date. It has been discovered that swan, sheep, vulture, reindeer even human bones haven used to make wind instruments. Bone-made instruments get yellowish and cracy over time (Atema, 2014; Atema, 2004; Buisson, 1990; Morley, 2013; Conard and Malina, 2008; Conard et al., 2009; Barclay, 1997; Huffer and Chappell, 2014; Thom, 2008; Wilford, 2012; Dickens, 2007; Pomberger et al., 2018).

Horns could be defined as an animal origin instrument making raw material those have been used by animals as a social status symbol once in their herds by deer cattle, goats, sheep; which is conical shaped, cosisting a bone tissue and keratin[4] surface that protects the bony tissue (Taşkın, et al., 2017). Shofar[5] is made of horn and bugles (used in military bands), are good examples for these instruments. Some instruments which look like horn and imitate its sound are in a sub-class of wind instruments, this class is called 'Horn'. This instrument has been used in orchestras since 17th century (Encyclopædia Britannica, 2019; Ülker, 2008; Çokamay, 2012; Vural, 2016a; Vural, 2016b; Barclay, 1997; Thom, 2008).

Ivory is the one of the oldest known raw materials used for the production of musical instruments. Some good samples were made 30 thousand years ago. They seem to have been made as skill needed as those which are produced today. Some other examples which were made in the 18th century have also been traced. Getting yellow and having cracks may ocur over time on the surface of the ivory as it does on the bone. Because of being as hard as bone and having a different structure from it, it has been possible to make various different wind instruments (Münzel et al., 2002; Conard and Malina, 2008; Morley, 2013; Conard et al., 2009; Barclay, 1997; Huene, 1995; Powell and Lasocki, 1995; Solum and Smith, 1992; Powell, 2002; Bate, 1969; Thom, 2008; Wilford, 2012; Dickens, 2007).

Herbal Origin Organic Materials

Due to the weak forms of their nature, only very few of them have been able to lived up to our time, although they might be probably one of the oldest wind instruments. Boxwood[6], ebony, cocus and rosewood have been mostly used. In some places endemic materials were used, such as, bamboo, reed and plum wood for the regional instruments. Some woodwind instruments like flute, have been replaced by metal-made ones because they are easier to carve or craft on it. But some others, like obua and fagot, are still made of wood in traditional way or

[4] Keratin is found in hair, fingernails, hoofs, horns, wool, bird feathers and in epithelium cells, it is a kind of protein which has a fibrous structure. It is claimed that it has structural and preservation functions (Encyclopedia Britannica, 2019)
[5] Shofar is Jewish religious instrument and it usually is made of ram horn.
[6] Boxwood was used in a widespread way during Baroque and Classical periods, but nowadays it is quite rare to obtain, so it has been replaced by Venezuelian boxwood the density of which is low (Solum and Smith, 1992).

modern production methods. In the performance of some music which belong to a particular geographical region or to a particular period[7], it can be said that these instruments are preferred by performers and orchestras because of their original tone[8]. (Thom, 2008; Barclay, 1997; Baines, 1991; Toff, 1996; Simon Fraser University, 2019; Huene, 1995; Powell and Lasocki, 1995; Solum and Smith, 1992; Powell, 2002; Bate, 1969; Raven, 2017; Kendall, 2010; Larue, 2015; Dickens, 2007; Vitullo, 2013).

Synthetic Organic Materials

Synthetics are artificial raw materials to imitate a natural product which have been made through organic chemistry, from simple to more complex structures via chemical synthesis. (Oxford Dictionary, 2019; Merriam-Webster Dictionary, 2019; Encyclopædia Britannica, 2019).

Synthetic organic sources generally come out through a chemical reaction called 'polymerisation' (Atkins and Jones, 1998; Saçak, 2006). Polymers are various chemical organic compounds which are produced by way of successive repetition of organic molecules called monomers[9]. Polymers which are used in the production of the wind instruments are divided into two main groups: Thermosets and Thermoplastics.[10] Thermoset polymers come out at the end of certain chemical reactions by means of their strong ties between their molecules (covalent ties), they are more durable and can preserve their shapes at the end of the reaction against heat (e.g. bakalite). Thermoplastics are amorphous[11] solid matters which have weaker molecule ties. Their shapes can be changed by heating more than once (when heated they melt and hardened when cooled) (Eskizeybek, 2012; Atkins and Jones, 1998; Saçak, 2006; Aras and Tunalı, 1982).

Ebonite is defined as a hard synthetic thermoset polymer, which is caused by the raw rubber obtained from the rubber tree to be subjected to a chemical process called vulcanization[12]. Ebonit which is also called hard rubber has given its name beause because of blackish color and it is used as a substitute of ebony. With the expansion of petroleum-based polymers, the demand for Ebonite, which is more hard and costly to produce, has decreased. Though some wind instruments have been made of Ebonite, in some instruments for which reed is used, such as

[7] There are opinions claimed that using the instrument of a spesific period might be a wrong approach due to these insufficient technical features of it during the performances of flute pieces (Wente, 2008).

[8] It is seen that there are studies, findings and arguments defending that the raw material which is used for the production of flute does not affect the tone of the instrument (Dickens, 2007; Widholm et al., 2001; Coltman, 1971).

[9] Polus: Many, a lot of; Monos: Single, only, by itself; Meros: Particul, little piece. These are antique Greek words.

[10] Thermos: Hot; Plastikos: To give shape. These are antique Greek words. Set: Adjust, regulate, harden. These is an English word.

[11] Amorphous solid matters do not have regular molecular ties as in the other solid matters. They have irregular ties as in liquids. They do not have a specific melting point, so they have a heat range during which they soften when heated. Glass and thermoplastic polymers are good examples for amorphous solid matters (Aras and Tunalı, 1982).

[12] Vulcanization is a method by means of which polymers are obtained. It enriches the material in terms of different features. These features come out when caoutchouc, sulfur, catalyst, activator are used together with heat, pressure and time variables. These are used in different ways. Car tires were invented by Charles Goodyear at the end of the 19th century by means of vulcanization (Kişioğlu, 2003).

saxophone has Ebonite made mouth pieces (Barclay, 1997; Bate, 1969; Dickens, 2007; Nikko Ebonite, 2019; sax.co.uk, 2019; Bigio, 2011).

There are synthetic thermoplastic polymers such as ABS (acrylonitrile butadiene styrene), wind instruments produced especially by using 3D printer technology (Thom, 2008; Zoran, 2011).

Inorganic Materials

All the other materials except for those the source of which is not obtained from an animal, a plant or any of the organic chemicals (which had to have carbo-hydrate ties) are called inorganic materials or minerals (Altıntaş, 2013; Merriam-Webster Dictionary, 2019; Oxford Dictionaries, 2019).

Inorganic materials which are used in the making of wind instruments can be studied in two main groups: Metals and Non-Metallic Minerals[13]

Metals

They can be melted, their shapes can be changed by hammering, can be poured into mold in liquid form and they are god conductors of heat and electricity (Özbek and Kınayoğlu, 1988).

Some wind instruments can be produced out of metals, metal alloys[14] and also they can be plated by different metals. 'Brass' instruments contain high degree of copper and zinc. The group takes its name from the metal alloy. Silver, gold, brass, copper, bronze, aluminium, platinum, steel and recently titanium are raw materials which are frequently used. Tin is a raw material used for the production of tin metal plates and especially used in Ireland to make tin whistle which is a folk instrument (Clarke Tin Whistle, 2019; Dikmen, 1975).

Silver and gold are often used as a material of alloy and plating. Due to its high conductivity, silver is very often used for making metal flutes. Since it is a quite valuable metal, it is used as only plating or low alloy material for the sub-class flutes, for the more valuable flutes it is used in high degree (e. g. Sterling Silver. 925). As for gold, it prevents from corrosion and other harmful environmental conditions but it almost never gives any harm to the heat conductivity. There also are flutes that made of pure gold or an alloy which contains certain degree of gold. (Toff, 2017; Baines, 1991; Baines; Powell, 2002; Barclay, 1997; Dickens, 2007).

[13] In working and production of some raw materials belonging to non-metallic minerals, metals are also added to the production process, but depending on the chemical features which differ some metals and non-metalics from each other in terms of conductivity and insulation. According to this, the headline of 'non-metallic minerals' have been found more suitable.

[14] All the mixtures which combine all metals with each other are called 'alloys' and all metals can form alloys with each other (Aras and Tunalı, 1982; Atkins and Jones, 1998).

Even though there is a belief that the more expensive the raw material is, the more quality the flute has, there are some researchers who claim such a criterion is not sufficient by itself in order to determine the differences between flutes (Dickens, 2007; Widholm et al., 2001).

Non-metallic Minerals

Non-metallic minerals do not have neither chemical nor physical features as metals, generally have a molecular crystalic structure (Aras and Tunalı, 1982; Altıntaş, 2013; Atkins and Jones, 1998).

Glass is an amorphous hard solid, its melting point is high and it does not have a crystallic structure. That is, glass behaves as if it is a liquid which the fluidity of has been quite lessened. Therefore; it does not have a certain melting point, but instead, a heat range during which it begins to soften. It can be said that once there were glass-made wind instruments and they were produced skilfully (Dikmen, 1975; Aras and Tunalı, 1982; Barclay, 1997; Vitullo, 2013; Sperling, 2018; Özbek and Kınayoğlu, 1988).

Clay materials, Terracotta (clay, baked earth) is baked at high heat and the structure of the chemicals, which clay contains, changes and becomes crystalized. It has been seen that Terracotta wind instruments have been used since ancient times (Solis, 2012; Thom, 2008; Pomberger et al., 2018; Offermans, 2019). Other clay materials are used for making porcelain and ceramic, they have a shining feature because of different additive matters in their structures (Özbek and Kınayoğlu, 1988). Also it might be seen that there are some other wind instruments has been made of these too (US Patent No. 0272473 A1, 2006).

There are wind materials which are made of valuable stones or semi-valuable stones (such as, jadestone and marble). Some of these instruments are processed in a special way, but a Japanese wind instrument called 'Ishibue', has a natural hole on it or a hole is opened or corrected at a suitable place of an ordinary stone (Offermans, 2019; Tanaka and Nogawa, 2013; Mair, 2006).

Composites

A composite structure contains atleast two raw materials which have different chemical and physical features than each other. They are combined in order to develop the desired features (Eskizeybek, 2012; Barclay, 1997).

Composite structures can be studied in two main groups: Resinous and non-resinous.

Resinous Composites

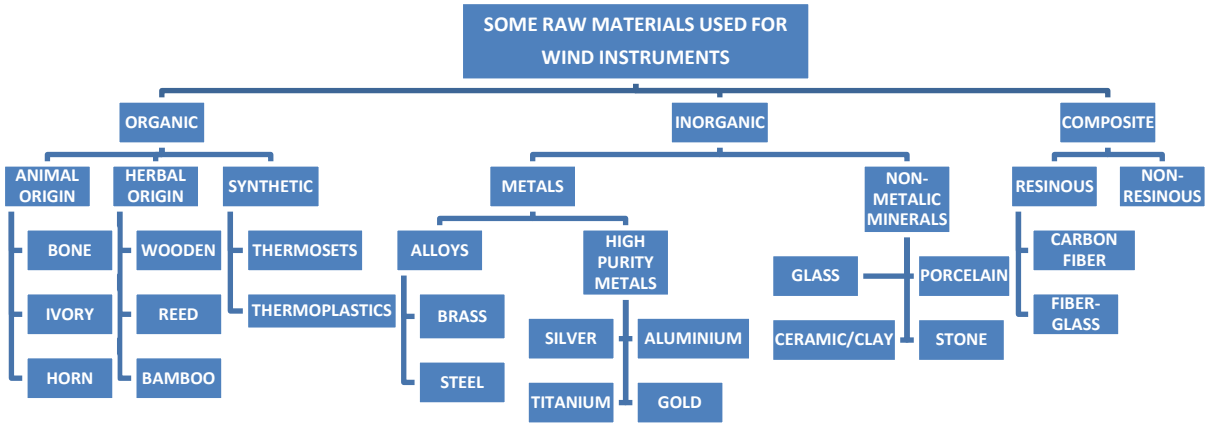
Polymers are the main content of a resinous composite, which generally keep the composite material together, at the same time give a durable mechanic feature structurally. These polymers which called resins, could be thermoset or thermoplastic, they are composed to tie (called 'matrix', e. g. thermoset polymer) and connect the 'additional materials', such as fibers that form the skeleton of the material and other additional materials (Eskizeybek, 2012).

Carbon fiber has fibers which made of carbon and other carbon-based structures (e.g. kevlar). They are formed by using additional materials and thermoset polymeric resins together like Epoxy which is a composite material with a high durability. Fiberglass is a composite material that contains glass fibers in it. The brand 'Matit' has flutes that made of carbon fiber and there is also an instrument called 'Didgeridoo', which is an Australian regional instrument, has its kinds made of fiberglass too (Eskizeybek, 2012; Toff, 1996; Wiggins and Storey, 2010).

Non-resinous Composites

They could be defined as materials which has more than one raw material have been used together in its production. That is, organic or/and inorganic structures can be used in a combination. In wind instruments, many mouth pieces or body combinations, in fact, can be easily defined as composite. Especially, in The Baroque Period, wood instruments had metal or ivory details (Bate, 1969). These kind of details are used in order to ornament the instrument and these details prevent the harm that the additional pieces might give to the main body of the instrument (Powell, 2002). Various wind instruments produced by the elements of the composite printing, which was provided by 3D Printer Technology (Ashrafi et al., 2011).

Table 1. Some Raw Materials Used For Wind Instruments



CONCLUSION

When all the wind instruments are reviewed in terms of kind and types all over the world, it is seen that they constitute the most widespread instrument. Because it is easy to carry, it can be produced from a tubular hollow cylinder and it has an idiosyncratic sound.

The classification obtained through that research is also applicable for other instrument classifications. Thus, it will be possible to understand which instrument can be produced by which raw material and which production technology could be used for it.

It has been seen that bone was an important means of animals so in order to produce music for the primitive humans and it has been able to reach our time. Because it is hollow like reed but more durable than it, it is as well a by-product of animals so it has permanence. Using ivory to make a wind instrument must be argued. Because it does not have an affect on the tone of the flute, besides it causes the extinction of elephants.

Synthetic polymers are raw materials that have an important role in our lives. They are obtained from petroleum by means of different organic molecules and their different structures together with different physical and chemical features. It has been possible to produce various wind instruments by using plastic injection method and 3D printing technology. They give a lot of hope to fulfil the needs of the art for future which is already growing. It is because its production cost is low and spare parts are easy to produce too.

To protect the metal instruments from the environmental conditions and corrosion, noble metals are often used as covering. Gold is a delicate raw material, because of being very expensive and very soft metal like copper with a relatively high melting point, so it requires a great skill to work with. On the other hand, there are some arguments put forward by some of the other researchers that the raw material of a flute does not affect its tone.

Composite structures are quite functional in terms of combining the features of two different raw materials.

Even though it is different in terms of its raw materials e.g. the flute, is composed of simply a hollow cylinder. The changes applied on the cylinder are the differences which determines it. In what way this cylindrical structure will function depends on the working technologies of the raw material.

The materials which are used in our time have been shaped by the technological breakthroughs that we have passed through since the beginning of human history. The man who had worked with stone or bone learnt how to work with a mineral ore. Since the Industrial Revolution, by-products of petroleum have been used as a synthetic raw material. Along with the discovery of raw materials such as fiberglass formed by the combination of glass fiber and resin and carbon fiber produced by similar techniques, composite materials produced by using all other raw materials together surround us in daily life. It has gained great importance that we can make in our homes since 3D printers took place in our daily lives and it has become easier to reach knowledge by means of computer.

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