Reducing the Environmental Impact of Cork Waste by Improving Natural Asphalt as Water Proofing Material

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Abstract

This research is concern with two principles, a) the environmental pollution which is the global problem b) the economic benefits as a result of reusing of waste material such as corks to produce new reusable material like Modified-Asphalt. In this research cork has melted by benzene and mixed with Hit Natural Asphalt to get good paste with weight percentages of 0%, 10%, 20%. The properties of Modified –Asphalt have been studied after and before adding coke. The results revealed that adding coke by 29% can make the Modified –Asphalt meets the international specifications (ASTM D312) and Iraqi specifications (88-1196) as a Water-proofing material.

Keywords: *environmental impact, natural asphalt, cork waste, modified –asphalt, water proofing material*

Introduction

Cork is important in all aspects of practical life because of its applications and advantages. One of the negative results in the use of cork is the accumulation of large amounts of waste consumed and the time to get rid of them. Since most of the cork does not decompose rapidly, its waste has contributed significantly to environmental pollution. These industrial wastes accumulated and started to threaten human health and all elements of the environment. It has been found that some of these wastes such as cork can be controlled by the recycling process [(1)]. Some people may have to get rid of the waste of cork by burning it and this leads to direct or indirect impact on water, soil and air, as the combustion of waste cork leads to the emission of many chemical compounds depends on many factors, including the type of cork, the speed of combustion, the size and quantity of cork waste, ambient temperature and humidity. Combustion gases are the most emitted chemical compounds e.g. carbon monoxide, carbon dioxide and sulfur dioxide, as well as polycyclic aromatic hydrocarbons such as Pyrene and Anthracene. Other emitted materials include hydrocarbon compounds e.g. xylene and gasoline. The incomplete combustion of cork leads to thermal chemical decomposition followed by the re-unification of parts of various chemical components, some of which are liquid, such as aromatic compounds or paraffin carried by water used in extinguishing the fires.

Scientific methods for safe recycling of cork products

The safe scientific methods for recycling cork depends on its nature and behavior and the quality of the additives and the treatments. All the plastic products can be recycled again through some suitable methods to be reused in their own fields. This can contribute significantly and effectively to sustainable development processes. The recycling of cork products is one of the most important modern processes that must accompany with the expansion of the use of cork products as alternatives to traditional known materials and to achieve sustainable development programs[(2)] .

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Asphalt improvement processes

Improvements of natural or industrial asphalt are designed to increase the ability of asphalt to withstand external conditions to make it more suitable for industrial purposes. There are several methods used in this field as follows:

Binder additives

This type of improvement includes the addition of a polymer such as thermoplastic or rubber, where the link forms bridges between asphalt and other materials, which increases the bonding strength of the asphalt with the rest of the components. Here are several types of polymers used to improve asphalt e.g. rubber (styrene-butadiene) (S.B.R) as well as polyvinyl chloride (P.V.C) .The polymer bonds give an improvement in asphalt surface and in thermal properties [3].

Modifications of hydrocarbonic chains

In this method, there is an alternative reaction of hydrocarbon chain of compensators. These processes include the replacement of hydrogen atoms with other more polarized assemblies to strengthen the chain construction to become more powerful, giving the asphalt more solid and weather-resistant form. These methods include chlorination processes involving the substitution of chlorine atoms instead of hydrogen atoms in hydrocarbon chain of the electrode[4] or the addition of sulfur element. In this way, the double bond of sulfur ions is used to connect each successive hydrocarbon chain to each other, or to react with aromatic substances that are compensated by assemblies or by adding phosphoric acid.

Fillers additives

This method includes the addition of substances in the form of fillings of inorganic salts, waste or other materials, which reduce the spaces between the particles to give support to the body of asphalt and increase the adhesion between the asphalt particles through the formation of links (chemical, physical). Examples of fillers include, metal powders, oxides, metal chlorides and alkaline soils. Researches confirm the improvements achieved using these materials, especially when granular size is small and the material dried to ensure good homogeneity between hydrocarbon chains and improved materials[5].

Previous studies

Extensive studies were conducted on natural asphalt in an attempt to improve it. (Lee et.al) [6] studied the temperature affecting the chlorinated polyethylene mixture as an improved asphalt using different granular size and noted that the additive has increased the penetration and the penetration number when flexible polymers are used as an additive. McGennis[7] used tire crumbs to produce low-hardened asphalt. This was confirmed by a study by Saez-alvan[8], where the addition of polymer was found to give smoothness to the asphalt surface with an improvement in adhesion and thermal properties of asphalt[9,10]. Shatnawi[11] also confirmed that rubber gives good physical properties to asphalt.

A study by Qadi et.al[12] for the prediction of dynamic behavior of asphalt at high temperatures using common polymer-rubber and copolymer-polymer. The modified asphalt has a good rheological properties.

Mahmood et. al[13] improved the properties of natural asphalt using the powder of waste tires. The results showed that the resulted mix can be used as a Water-Proof material for roofing according to local and international standards.

HMAN[14] presented a study to improve asphalt specifications using 25% recycled non-metallic waste material in granular size (0.07-0.09) mm^3. They obtained a good results where Viscosity was 1220 centigrade at 135 °C, Penetration 53.7, Softening Point 54 °C, and the Ductility was 43.5 cm at 15 °C.

Many types of polymers have been successfully used to improve the cohesiveness of asphalt associated with its components at low temperature. This is confirmed by the study conducted by Kim et. al [15] . In recent years, the polymer has been widely used to improve the specifications of asphalt . Thermoplastics are the commonly used materials mixed with asphalt to enhance the cohesiveness of asphalt mixture.

Ghaly[16] has added the Atactic to hot asphalt and combined it with rubber (styrene-butadiene). The results showed an improvements in the rheological properties of asphalt at different temperatures.

The aim of the research

The aim of the study is to achieve two goals:

1. Utilizing natural asphalt as well as expanding its use by assessing its properties and improving it by adding cheap local materials such as cork.

2. Reduce the harmful effect of cork waste on the environment, which is constantly increasing.

Experimental part

Instrumentals

Table 1. shows the instruments used in this work.

Table (1) Devices used in the research.

№	Device	Company	№	Device	Company
1	Penetrometer	The Central Ignition Co.London	5	Digital Water Bath	Nickel Electrro LTD England
2	Fourier Transform Infra-Red (FTIR)	FTIR-8400 SHIMADZU (JAPPAN)	6	Hot Plate with Magnetic Stirrer	Lassco India
3	UV-Visible Spectrophotometer	CARY 100 Conc VARIAN AUSRALIA	7	Sensitive Balance	Sartorius Germany
4	Air Electrical Oven	Engineering Laboratory Equipment Limited.England	8	Hot Plate	Jenway United Kindom

Chemical Materials

1- Hit Natural Asphalt HNA: obtained from the city of Hit 200 Km to the west of Baghdad, Iraq.

2-CCl_4 carbon tetrachloride (95% purity).

3-Cork waste.

. 4-Gasoline to dissolve corke

Procedures

1-Sampling

A sample of HNA was taken and dried in the air to get rid of moisture. A specific weight was taken and placed in the oven for five hours at a temperature of 110 °C until the moisture was completely removed. The loss in heating of the sample was measured before other measurements were made.

2-Preparation of cork paste

The cork was cut into small pieces after being thoroughly cleaned and then dissolved in gasoline for 10 minutes at room temperature. After that, the cork paste was added to HNA at 0%, 10% and 20% percentages.

Tests 3-

a) Penetrometer. This instrument is used to conduct Penetration test according to ASTM D5 (17).

b) UV. Visible Spectroscopy (18).

c) Infrared Spectroscopy (19).

Results and discussion

1-Penetration Results

Figure 1 shows the positive effect of adding cork to HNA on the results of penetration test. Cork increases the stiffness of the asphalt as can be explained by decreasing the values of penetration from 210 (0.1 mm) at zero percentage of Cork/Asphalt C/A to 95 (0.1 mm) at 20% C/A.

This may be due to the chemical rapprochement between materials (cork and HNA) since both are hydrocarbon substances. This can provide greater adhesion and cohesion between them as well as the occurrence of physical overlap or fusion between the two materials.

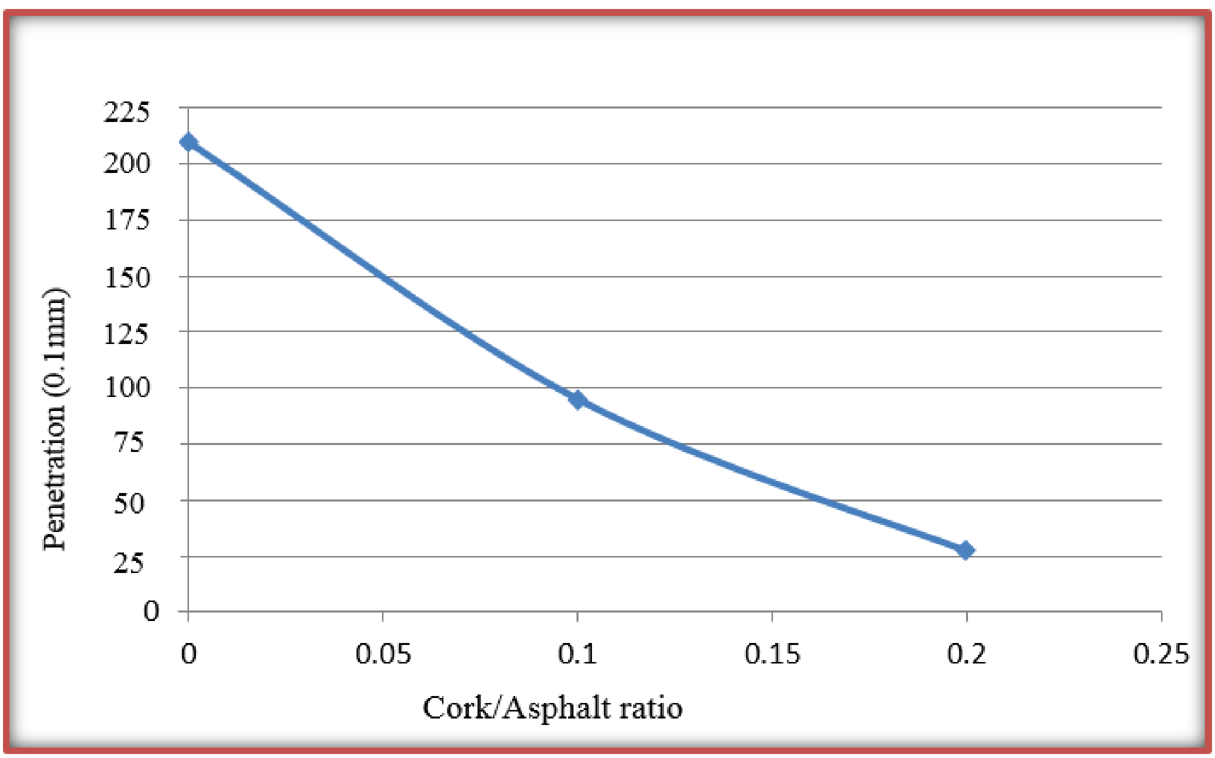

Figure 1. The effect of cork percentage on the penetration of Cork- Asphalt mixture.

Spectroscopy Results:

FT-IR) a) Infra-Red Spectroscopy

The FT-IR spectroscopy for modified HNA samples was performed to determine the location of bond absorption after diluting the models using carbon tetrachloride (CCl_4). The model was then placed on the disk for a period to help the evaporation of the solvent.

After that the measurement was performed [18].

Hit Natural Asphalt HNA **with Cork Paste**

When the cork paste was added to the HNA by 10% and by 20%, the spectra did not show much difference. A slight difference was observed in the model (HNA + 10%, 20% Cork paste). This may be due to the formation of hydrogen bonds between the cork paste and HNA which caused displacement of the positions of the absorption of certain bonds as shown in figures 2 (HNA), figures 3 (HNA + 20% Cork paste) below.

The properties of some of the beams have little effect on the chemical composition of the HNA, which means that there is a physical mixing rather than chemical reaction between the Cork paste and HNA.

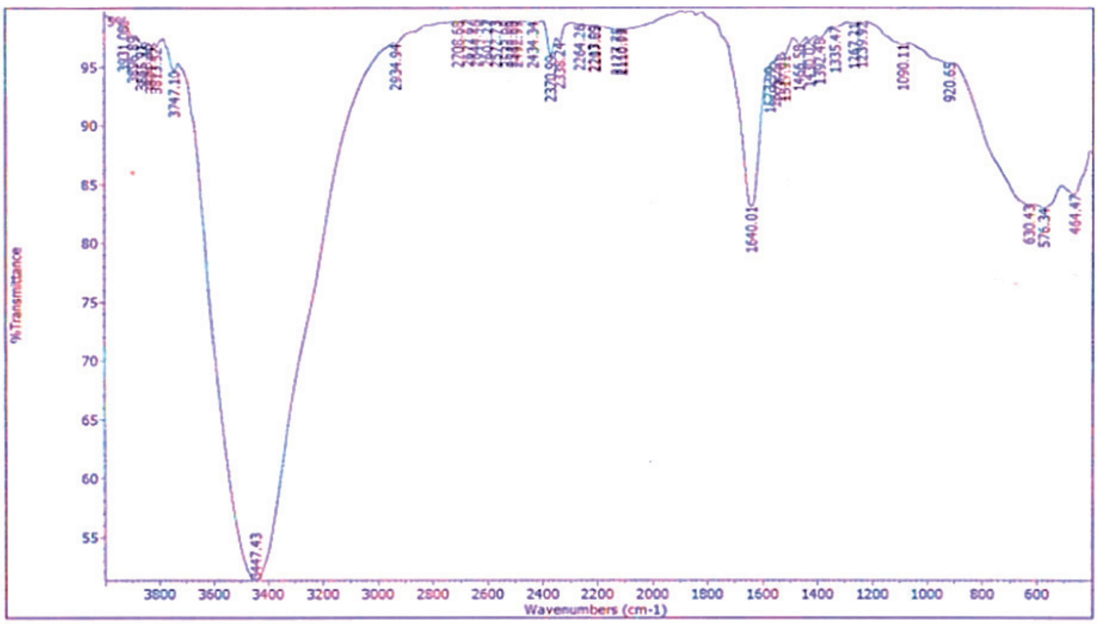

Figure 2. The FTIR absorption spectra of natural asphalt.

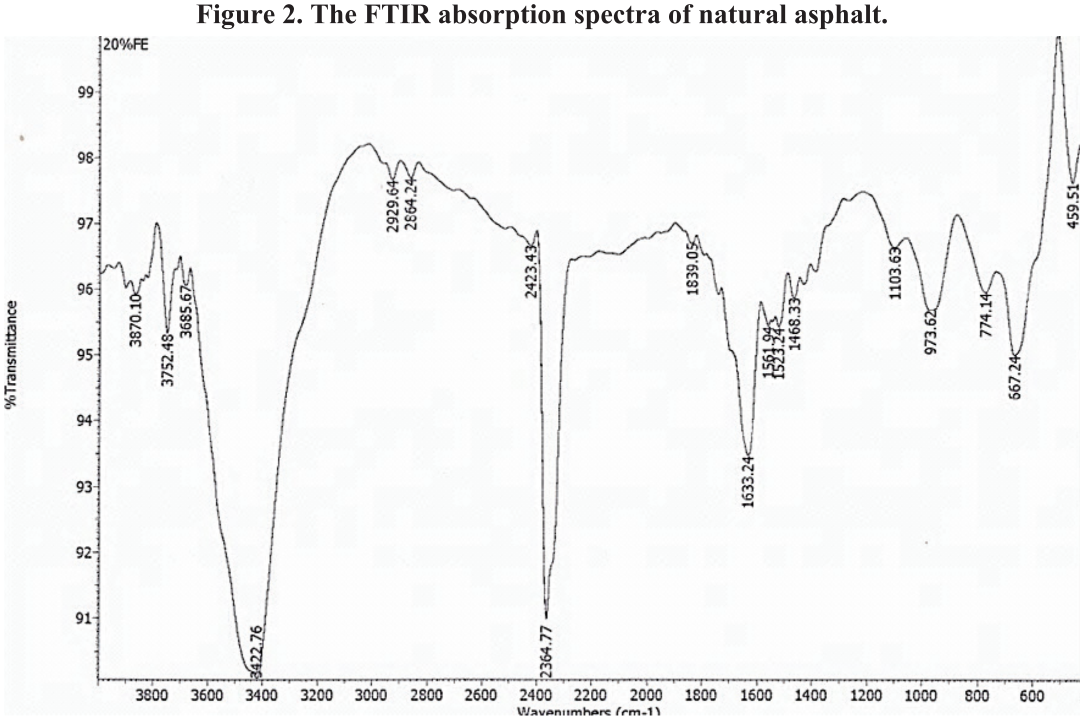

Figure (3) FTIR spectrum for natural asphalt at 20%

UV- Visible Spectroscopy

Hit Natural Asphalt HNA **Results**

The UV spectrum of HNA has two bands:

The first (407.77 nm) was at the absorption of 0.36 This could be due to the excitement type π-π^*.

The second (267.46 nm) was at the absorption of 1.36. This can be due to the excitement type π-π^* as illustrated in figure 4.

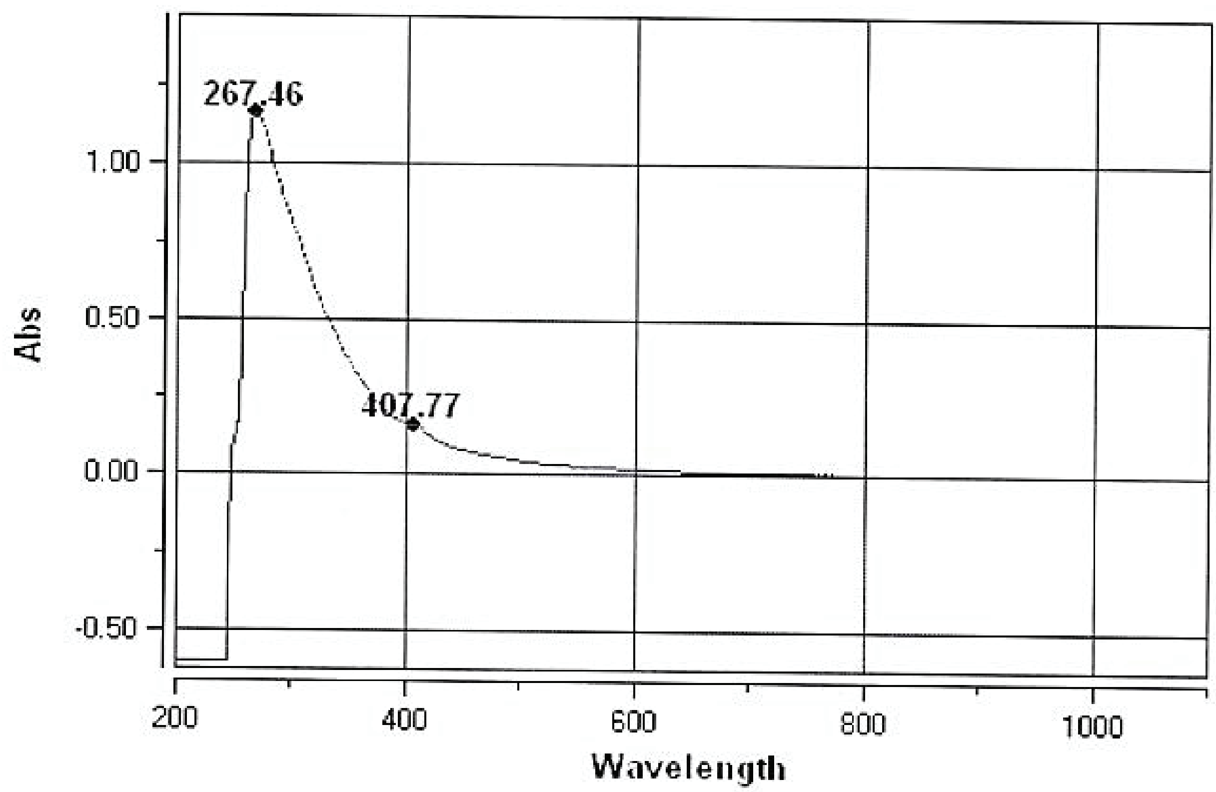

Figure (4) UV absorption spectrum for HNA

Hit Natural Asphalt HNA with Cork Paste Results.

When cork paste was added to HNA at 10% and 20%, the spectrum did not appear to be significantly different from HNA before the addition. The same beams of absorption were shown with the wavelength shift to the longest (red shift) for the transition π-π^* at 268.44 nm . It is also possible to observe a blue shift for the transition from π^*-n at 407.06 nm, i.e. wavelength shift to a lower value. These two displacements (red and blue) are caused by the dissolving of the substance in benzene where a change occurs in the polarization location as shown in figures 5.

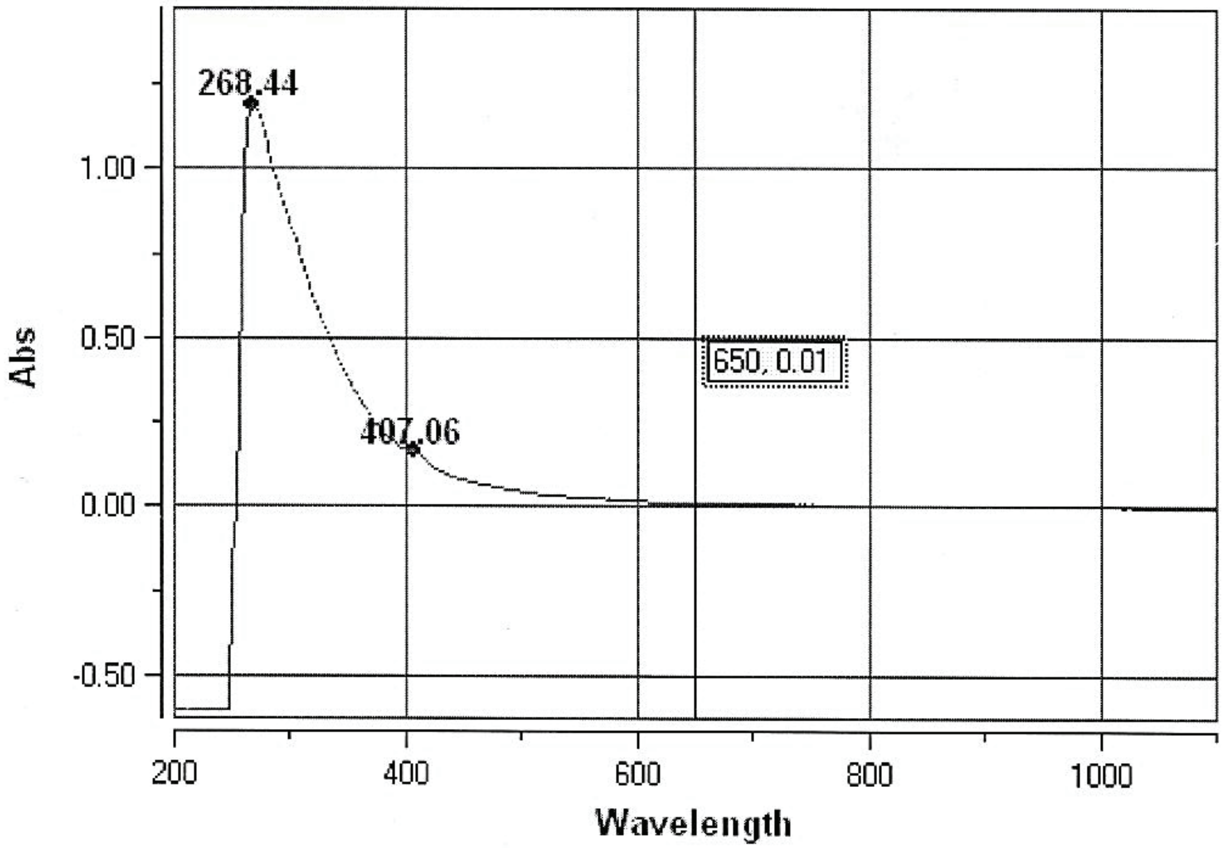

Figure (5) The UV spectrum for cork paste with HNA at 20%

Conclusion

1-The results show that adding the cork paste to HNA at 20% resulted in a new type of asphalt can be used as water proofing materials for the applications in roofing and satisfied both the international standard ASTM D312 and the local Iraqi standard IQ (88-1196) .

2-The new product can be used as a new cheap roofing material.

3-The study clarified that HNA can be used to produce new beneficial material instead of disposal into ground.

4-it can be claimed that it is possible to reduce the harmful effect of cork waste on the environment and humans and can be recycled into a new useful materials by improving natural asphalt.

5- The chemical composition of HNA-Cork mix is not different from HNA chemical composition. This indicates that the improvements in HNA are due to the physical mixing between the components as shown in the results of the spectroscopy tests. This is agreed with the findings of other studies .

Ethical Clearance: The Research Ethical Committee at scientific research by ethical approval of both environmental and health and higher education and scientific research ministries in Iraq

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