GSC Biological and Pharmaceutical Sciences

eISSN: 2581-3250 CODEN (USA): GBPSC2

Cross Ref DOI: 10.30574/gscbps

Journal homepage: https://gsconlinepress.com/journals/gscbps/

GSC Online Press

(Research Article)

Production and potential application of wood tar in dermatology and cosmetic

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GSC Biological and Pharmaceutical Sciences, 2025, 30(03), 233-248

Publication history: Received on 03 February 2025; revised on 13 March 2025; accepted on 15 March 2025

Article DOI: https://doi.org/10.30574/gscbps.2025.30.3.0108

Abstract

In recent years, the limited supply and strong demand for fossil fuel led to its fluctuating prices. Biomass has attracted a lot of attention as a renewable resource to replace fossil fuels in the production of energy. Pyrolysis provides an efficient method to convert solid biomass into transport fuels and valuable chemicals. As such fuel, charcoals are produced with earthen kiln by smallholders in Sub-Saharan Africa (SSA). Traditional kilns release combustion smoke which is very harmful to the environment as well as human health. The products of the processes taking place include, in addition to charcoal, a distillate comprising non-condensable, condensable gases (Pyroligneous acid and Tar) and vapours. In this review, it is attempted to explore tar's potential use in dermatology and cosmetic in the SSA region. Consequently, considering the long experience with wood tar therapy and its worldwide usage suggests at least that their use should still be considered for skin care in dermatology and cosmetic. This paper highlights the potential benefits arising from wood tar application in dermatology and cosmetic.

Keywords: Wood Tar; Pyrolysis; Cosmetic; Dermatology

1. Introduction

Nowadays, energy is an important topic for many countries around the world due to concerns about environmental changes and fluctuating energy prices. Heat and power generation from alternative and sustainable resources have then become a primary focus of research in the field of energy efficiency and renewable energy. One of these resources is biomass, which is the third source of fuel on the planet and has the potential to be clean and renewable [1]. Energy has been obtained from forests for thousands of years and forest remains the largest contributor to the current global biomass supply [2]. Wood from forest biomass represents an abundant renewable source of readily available energy on combustion [3], [4]. In sub-Saharan Africa (SSA), especially in rural areas, smallholders produced charcoal from wood by using an earthen kiln. In addition, charcoal as a locally available and relatively clean fuel compared to burning wood is then sold or used for cooking. This traditional use of wood is inefficient and characterized by severe negative impacts on human health by the combustion smoke. The modern uses of wood are characterized by more efficient and cleaner technologies. Wood carbonization is now used with modern kilns. It produces three main products (Figure 1): charcoal, liquids, and gas [3]. The liquids obtained as one of the products of the carbonization or destructive distillation of wood, usually separate into an aqueous and oil phase. The latter is also called wood tar [3].

As the interest in using environmentally safe materials and products increases, many researchers were focused on developing low-cost and eco-friendly cosmetics and drugs. Tar extract of many kinds of wood was studied extensively and many of them proved to possess activity. Generally, *Pinus sp., Juniperus sp., Fagus sp., Betula sp., Picea sp.,* and *Cedrus sp.* tree species are used for tar production. Tar has many properties, including bactericidal, antiseptic, and anti-

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inflammatory and is used in medicine [5], [6]. Wood tar had numerous applications, including serving as a universal source of grease and glue, insulation for building and ship hulls, skin and wood preservatives, and traditional medicines [7]. Due to its strong antiseptic effect, this compound is used in veterinary medicine for the treatment and care of hooves (concentration range 1–30%) [6]. Skin diseases are among the most common health problems that human beings suffer from. Wood tar has been used for its pharmacological properties in European, North African, and Mediterranean countries. For the treatment of skin diseases, wood tars have been used [8]. It is widely used for alleviating inflammatory skin reactions. Since antiquity, topical pine tar has been successfully used in medicine to treat a variety of skin disorders, most notably eczema, psoriasis, seborrheic dermatitis, and other dry, itchy, flaky, or irritated skin conditions [9], [10]. Cade oil, obtained by carbonizing the trunk and major branches of old cadiers, was previously used in cosmetics and human health. Today, some shampoos contain cade oil [11]. In sub-Saharan Africa, smallholders do not recover condensable gases (Pyroligneous acid and Tar) released by traditional kilns because they don't know its benefits. Wood tar generated in the production of charcoal has the potential to be exploited. As environmental and sustainability problems increase, waste disposal becomes increasingly important, and new recycling methods are being sought. Such knowledge is also imperative to help charcoal producers to produce clean energy and optimize their incomes. It is also helpful to provide natural resources for skin care in dermatology and cosmetics against cutaneous diseases. In this review, we are interested in evaluating tar's potential use in dermatology and cosmetic in the Sub-Saharan Africa region. Therefore, it is necessary to investigate tar production, the species that have been used in the process, chemical composition, and toxicity. As well as Tar's potential use in dermatology and cosmetic.

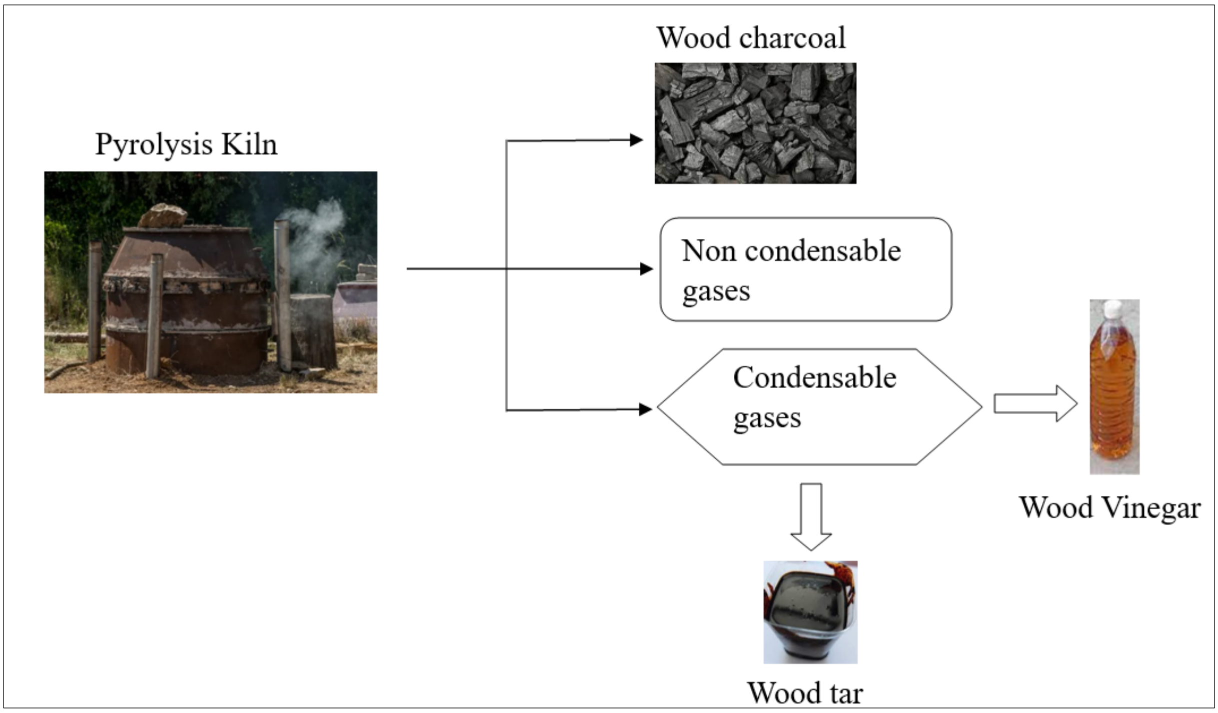

Figure 1 Main products of wood pyrolysis

2. History of tar uses

Since the Stone Age, wood tar has been known as an adhesive [12]. It is a black, sticky, and viscous material. Tar was made through the process of "destructive wood distillation" which consists of heating organic compounds to a high temperature without air access to separate them into simple components [13]. There are two types of wood tars: those made from trees with a high resin content (pine and juniper) and those made from hardwood trees (birch and beech) [14]. Wood tar exudates were extracted, in Europe and the Mediterranean, from various plant families depending on time and area: Pinacae (*Pinus sp., Cedrus sp., Larix sp., Abies sp.*) and Cupressaceae (*Juniperus sp., Tetraclinis sp.*) in conifers, and Betulaceae in hardwoods. They have been used since prehistoric times for their adhesive, water-repellent, repellent, and finally medicinal properties [15]. Birch tar has been used and produced since the Middle Palaeolithic period of Neanderthal [16], [17]. This oldest manmade adhesive was also extracted in North Africa from various wood species: *Tamarix gallica L.*, *Pinus halepensis*, *Juniperus phoenicea L.*, *Juniperus oxycedrus*. The informants mentioned the use of *J. oxycedrus, J. thurifera, J. phoenicea, T. articulata* and *C. atlantica, with J. phoenicea* and *J. oxycedrus* being the most frequent *Neriun oleander, Eucalyptus* and *Olea* were only used as substitutes for tar (commonly called Ar'ar) when this could not be found. *Pistacia sp*. was only used in small amounts. Some producers used a mix of species for their tar production [18].

Birch-bark tar has long been employed as an adhesive. Pieces of birch-bark tar dating back to the Middle Palaeolithic period and made by Neanderthal hunter-gatherers were discovered in a lignite open-mining pit near Königsaue, Germany. Tar from pine wood has probably been produced in Scandinavia since the Iron Age. It was extensively used across Europe from Norway to Greece in the Mesolithic [19] and Neolithic periods [20]. In ancient Greece, pine tar was also known [9]. In fact, Hippocrates described the use of pine tar in medicine more than 2000 years ago, and it has most likely been produced in Scandinavia since the Iron Age [21], [22].

Coniferous wood tars have been used to treat people and animals in countries such as Morocco and Turkey since prehistoric times for their adhesive, water-repellent, and medicinal properties [18]. Lebanon Cedar (*Cedrus libani* A. Rich) is a Mediterranean native with a pleasant odour and high value. In ancient times, it had a religious meaning and was used as a medicine [23].

3. Feedstock for wood tar production

3.1. Chemical components of plant biomass

Plant biomass is a promising renewable energy source. The biomass feedstocks are composed of three fundamental polymers: cellulose, hemicellulose, and lignin, as well as inorganic minerals and organic extracts such as lipids, proteins, simple sugars, starches, glycosides, alkaloids, resins, phenolic compounds, and essential oils [24]. The total amount of such biomass that is accumulated annually in the world is estimated that the world has at least 10 billion tons [25].

The plant cell wall is a network of inter-connected cellulose microfibrils coated by cross-linking hemicelluloses, whereas lignin, a complex phenylpropanoid network, is linked to hemicellulose via arabinoxylans or galactoarabinoxylans [26]. Hemicellulose is a heteropolysaccharide formed of monosaccharides like glucose, xylose, mannose, galactose, arabinose, 4-O-methyl glucuronic acid, or galacturonic acid residues, whereas cellulose is a homopolymer formed of -(1-4) linked glucose units (Carpita, 2000). Lignin is produced by polymerizing the hydroxyphenylpropanoid monomer, namely pcoumaryl, coniferyl, and sinapyl alcohols. This results in the formation of p-hydroxyphenyl, guaiacyl, and syringyl lignin units [28].

3.2. Potential source of feedstock for wood tar production

A variety of biomass feedstocks has been used to generate energy [29]. Through thermo-chemical processes, biomass such as woody plant, bamboo, agricultural, herbaceous plant, and algae can be converted into commercial products such as charcoal.

3.2.1. Woody plant

Wood tar derived from woody plants has been used to preserve rope, wood, for caulking, and in pharmacy as a component of some ointments and antiseptics. Many resin woods, as well as other wood barks, have the potential to be used as raw materials in the production of tar. Wood tars are produced from trees with a high resin content, such as pine and juniper, or from hardwood trees (such as birch and beech) [21]. Wood tar is frequently extracted from various source trees. The source tree determines the yield and characteristics of wood tar [30]. Juniper [31], [32] followed by Thuja, [32], Cedar [15], [33] and Pine [11], [34] is the most used species for tar production.

3.2.2. Softwood

Softwood is derived from conifers, which are typically evergreen. Literature sources [35] indicate that medicinal tars, such as Cade oil, are made in Morocco from various conifer species such as *J. J. phoenicea Tetraclinis articulate, thurifera*, or *Cedrus atlantica* [18]. Most tar-related studies indicate that tar production uses vegetable sources from coniferous trees, with coniferous trees being preferred as starting materials. Some woody trees such as *Juniperus sp., Pinus spp., Betula spp., Pijucea spp.,* and *Cedrus spp* have been evaluated to produce secondary metabolites that treat human and domestic animal diseases in local community. The most important of these secondary metabolites has been known as tar. [15], [36]. Resinous wood tars are distinct from hardwood tar in that they include turpentine, a fragrant combination of terpenes [37].

3.2.3. Hardwood

Hardwood is typically derived from deciduous trees, which lose their leaves each year. The trees used to make hardwood are typically slower growing, resulting in denser wood. Hardwood tars are made from pyroligneous acid, either automatically as an acid deposit or as a by-product of the acid's distillation. Crude pyroligneous acid is a condensed, volatile by-product of wood distillation. Hardwood tars are derived from oak, beech, ash, elm, and birch. Some deciduous tree species used for charcoal and wood tar production include beech *Fagus sp*., ash *Fraxinus sp.,* birch *Betula sp.,* elm *Ulmus sp.,* and oak *Quercus sp* [14].

3.2.4. Bamboo

Bamboos are a diverse group of evergreen perennial flowering plants in the subfamily Bambusoideae of the grass family Poaceae. The largest members of the grass family are giant bamboo. Bamboo was one of the fastest-growing plants, and the majority of it was found in Southeast Asia, Canada, and West Africa.

It has previously been demonstrated that different tars, including bamboo tar (BT) and wood tar, have chemical compositions that are similar, with minor differences in the types and proportions of phenolic compounds [38]. Bamboo tar is a water-insoluble semi-solid waste by-product of the bamboo charcoal industry. More than 90 different compounds have been identified in it, including homologues and derivatives of phenols (43.63%), alcohols (20.80%), benzenes (5.54%), ketones (4.63%), aldehydes (3.53%), organic acids (2.79%), esters (1.00%), and other minimal compounds (18.08%) [39], [40]. Bamboo tar to a promising botanical aphidicide [41].

3.2.5. Herbaceous plant biomass

Grasses used to produce biomass are one type. Herbaceous biomass includes feedstock derived from nonwoody plants grown for energy or from plant parts or residues [42]. Horvat investigated the effect of temperature, equivalence ratio, and biomass composition on tar yields and composition using Miscanthus x giganteus (MXG) as biomass feedstocks [43]. It appears that temperature is the primary driver of tar production and chemical composition; however, this study shows that tar yields are significantly affected by biomass composition.

3.2.6. Agricultural residue

A significant amount of agricultural biomass waste, such as wood, rice husk, palm kernel shell, coconut shell, and other agricultural residues, has a high potential for conversion into useful and commercially viable energy [44].

The impact of biomass torrefaction/carbonization on H_2-enriched syngas production and tar formation from the steam gasification process was thoroughly investigated [45]. Wheat straw (WS) was selected as an example of agricultural biomass. Wheat, corn, sorghum, and tobacco straws may be mixed with rice straw and other combustible wastes such as crop processing residues (peanut shell, rice hull, bagasse). They have the potential to be used in the production of charcoal [46]. The widespread commercialization of wood tar, as pyrolysis of agricultural waste, has the potential to reduce air pollution caused by careless burning practices, particularly in developing countries.

3.2.7. Algae

Because of their high growth rate (up to 20 g of dry algae per m^2 per day), widespread availability, high efficiency in CO_2 capture and solar energy conversion, and lack of competition with agricultural food, algae are a very promising feedstock. Seaweeds, which are classified as macroalgae, have several advantages over other types of terrestrial biomass. Some research has been done on the hydrothermal liquefaction of microalgae to produce crude oil. These investigations showed that the yield of bio-crude oil was higher than the lipid content of the microalgae indicating that oil is generated from the protein and carbohydrate components of algae in addition to the lipid fraction [47]. Research revealed that the bio-oil made from pyrolyzing macroalgae has a higher calorific value (HV) than the biomass of the algae [48].

Seaweeds do not require nutrient or water transport. This saves energy, and many types of seaweed have higher mass productivity than terrestrial biomass [49]. Catalysts improved both tar degradation and hydrogen production via water-shift reaction during steam gasification of algal biomass [50].

3.2.8. Production of wood tar

Tar is formed through a series of complex thermochemical reactions [51]. Among the thermochemical methods are burning, gasification, pyrolysis, and fluidization [52]. There are numerous biomass conversion techniques (thermochemical, biochemical, and physicochemical) that allow the release of inherent chemical energy and the generation of thermal energy or biofuels [53]. Thermochemical conversion is one of the technological options with enormous potential for providing substantial alternative energy [44]. Thermal decomposition reactions in the absence of oxygen, on the other side, allow for the recovery of solid and liquid fuels as well as valuable fine chemical by-products.

The reaction conditions have a significant impact on tar formation. Tar can be composed of over 100 different substances [51]. According to Konsomboon and colleagues, for all biomasses, the tar yields of biomasses after torrefaction were 42-62% lower than direct pyrolysis of raw biomasses [29]. Carbonization is a form of the pyrolysis process in thermochemical technology, which is the breakdown of complex substances, into simpler ones by heating [54], in the absence of oxygen [55]. Temperature, temperature increase rate, wood type and composition, and moisture content are all process variables that influence individual product yield. Dry distillation of wood with bark, on the other hand, yields more charcoal, tar, and gases [41].

3.3. Process of wood pyrolysis

3.3.1. Degradation of plant biomass during pyrolysis

As the temperature rises during pyrolysis, the plant biomass components depolymerize and fragment, resulting in the production of wood tar. Hemicellulose decomposes at a lower temperature range (200-320 °C), cellulose at 280-360 °C, and lignin at 140 to 600 °C. The homogeneous, unbranched crystalline structure of -(1-4) linked glucose units accounts for cellulose's narrow decomposition temperature range. The lower decomposition temperature of hemicellulose is due to the amorphous nature of xylan, which has many branched units with low activation energy [56], whereas the thermal stability of lignin is due to the cross-linked aromatic molecules. The pyrolysis vapours of xylan undergo secondary cracking at high temperatures (500 °C), yielding high water [57].

Solid char (charcoal, biochar) is produced, as well as volatile condensable compounds (distillates) and non-condensable gases. Distillates obtained as a result of carbonization or destructive distillation of wood typically separate into an aqueous and an oil phase. The latter is also called wood tar [3]. This liquid is a brownish liquid that is a complex and unstable mixture of many compounds, including phenols [58]. Tars are primarily formed during pyrolysis through depolymerization, and their formation is highly dependent on the reaction conditions [1]. Depending on the process, pyrolysis can be slow or fast [17].

3.3.2. Slow pyrolysis

Wood is slowly heated to the maximum temperature in traditional pyrolysis processes. Lower process temperatures (400 ºC) and longer vapour residence times facilitate char production [17]. Slow pyrolysis (low temperature, long residence time) increases charcoal yield, whereas fast pyrolysis (moderate temperature, short residence time) increases liquid-tar yield [59]. Other terms for this type of thermal process, in addition to slow pyrolysis, include carbonization, destructive distillation, and dry distillation [60]. The pyrolysis of wood was most likely the first chemical process invented by humans [61]. It often results in a raw distillate which separates into an aqueous phase termed pyroligneous acid and a dark non-aqueous oily bottom phase called pyroligneous tar which also has various applications [3], [62], [63], [64]. The ratio of these fractions depends on the feedstock, process, and storage conditions [65]. During the biomass pyrolysis, primary tar usually formed at a temperature range of 200−500 °C refers to a complex mixture of oxygenates that can be condensed into bio-oil [66], [67].

3.3.3. Fast pyrolysis

The fast pyrolysis of biomass is a promising energy conversion technology that produces bio-oil and high-value-added chemicals [68]. During fast pyrolysis, the biomass is rapidly (1000ºC/s) heated to about 500 ºC during a very short vapour residence time (< 2 s) and the vapours are then rapidly cooled to give a dark brown fluid liquid called bio-oil, pyrolysis liquid, or pyrolysis oil [17]. In this process, secondary reactions of pyrolysis tar inevitably occur and will affect the chemical composition of final products [69], [70]. Meanwhile, the yield of bio-oil would also be considerably influenced by the homogeneous reactions of primary tar. Therefore, a deeper understanding of the considerably influenced by the homogeneous reactions of primary tar [71]. The product proportion is influenced by feedstock properties and operation parameters (such as temperature, heating rate, particle size, etc) [50]. Typical product distribution for dry bark-free wood is, on average, 64 wt% organics, 12 wt% pyrolysis water, 12 wt% char, and 12 wt% product gas [17]. To obtain high yields of valuable liquid products product, the biomass particles must be rapidly heated and the residence time of volatile products must be short [72]. Pyrolysis of biomass in a fluidized bed provides a high rate of heat transfer to the reacting particle and high mass-transfer coefficients [73].

3.3.4. Chemical composition of wood tar

It has thousands of chemical components, the majority of which are aromatic hydrocarbons, tar acids, and tar bases [74]. Common compounds can still be noted. Tars indeed contain the majority of the fundamental molecular species such as acids, phenols, paraffinic or aromatic hydrocarbons [75]. The main constituents of tar were phenolics derived from lignin, while ketones, aldehydes, and alcohols were mostly originated from the decomposition of cellulose. The presence of phenol and cresol was attributed to both lignin and cellulose, but they formed in different ways [76]. The interesting observation was that as temperatures rise, the tar composition shifts to higher molecular tars as polyaromatic hydrocarbons (PAH). Phenols are important tar components at lower temperatures (pyrolysis) [51].

The thermal degradation behaviour of these components is used to classify wood tars [77]. They are divided into four main categories: primary, secondary, alkyl tertiary, and condensed tertiary tars [1]. The conversion performances of biomass are strongly influenced by the three major constituents of biomass; hemicellulose is the least stable polymer at temperatures ranging from 200 to 300 °C [29].

Cellulose and hemicellulose, which are high in oxygen, produce primarily oxygen-rich primary tar products such as alcohols, ketones, aldehydes, and carbon acids. Moreover, lignin produces bi- and trifunctional monoaromatics, which are mostly substituted phenols [51]. Lignin begins to soften at temperatures between 80 and 90 degrees Celsius, but degradation occurs only at temperatures between 250 and 500 degrees Celsius [29]. The temperature at which those primary tars form ranges between 200° and 500° C. The residual primary tars combine to form secondary tar, which is made up of alkylated mono- and diaromatics, as well as heteroaromatics such as pyridine, furan, dioxin, and thiophene [51]. Secondary tars, which primarily consist of phenolics and olefins, are produced by thermal cracking of primary tars at temperatures above 500 °C [1]. Tertiary tar with temperatures exceeding 800° C can be found. Tertiary tars are also referred to as recombination tars or high temperature tars. Tertiary tars commonly contain benzene, naphthalene, phenanthrene, pyrene, and benzopyrene polynuclear aromatic hydrocarbons (PAH). Tertiary tar structures are not found in natural biomass [51].

Another tar classification scheme is proposed in the study of Devi et al. that is based on the solubility and condensability of the tar compounds rather than their reactivity [78]. Tars are classified into the following groups, according to this scheme: GC- undetectable tars, heterocyclic tars that contain hetero atoms as well as highly water soluble compounds (pyridine, phenol, cresols, etc.), light aromatic tars that include light hydrocarbons with a single ring (toluene, ethylbenzene, xylenes, and styrene), light polyaromatic tars, which are two- or three-ring compounds (indene, naphthalene, methylnaphthalene, biphenyl, acenaphthalene, fluorene, phenanthrene and anthracene) and heavy polyaromatic tars such as fluoranthene, pyrene and chrysene which have more than three rings.

Light polycyclic tars condense at low temperatures, whereas heavy polycyclics condense at high temperatures, both at low concentrations [78]. As a result, using an appropriate configuration of the tar sampling method is critical for determining the tar production spectrum accurately [1].

3.4. Properties of wood tar

Two of these properties are unique to cade tar: antipruritic and keratolytic effects. These are caused by a variety of factors. The presence of phenols such as cresols is primarily responsible for the anti-pruritic action. Cresols and resorcinol have been linked to keratolytic activity. It is antiseptic and healing for various wounds and injuries, in addition to these two actions. The antisepsis is most likely caused by the cresol content [79]. It is indeed arthropodicidal as well as antifungal. Furthermore, cade oil has fungistatic properties due to its phenolic compounds [11].

3.4.1. Anti-microbial

Several studies have shown that some wood tars have antimicrobial activity. The traditional thermal method of obtaining cedar tar had a strong inhibitory activity on bacterial cells [15]. Antibacterial and antifungal properties of pine tar have been revealed [21]. Cade oil also has fungistatic properties due to its phenolic components. It is active against *trichophytons, Candida albicans,* and *Cryptococcus sp.* as well as *Aspergillus sp* [80]. By exhibiting antifungal properties against white and brown rot, TV, and NL fungi, which cause decay in wood, waste tar prevented weight losses in Scots pine and beech wood [81]. Table I listed some of the pathogens responsible for infections treated with wood tar.

Table 1 Example of some pathogens controlled with wood tar

References	**Pathogens**	
Mimouni [82]	Bacteria	*Trichophytons*
		Candida albicans
		Aspergillus sp.
		Cryptococcus sp.
Takci *et al.* [83]	Bacteria	*Escherichia coli*
		Staphylococcus haemolyticus
Al-Asmari *et al.* [84]	Bacteria	*Enterococcus faecalis (E. faecalis)*
		Pseudomonas aeruginosa (P. aeruginosa)
Mesut *et al.* [85]	Fungi	White rot fungus of *Trametes versicolor* L. (TV)
		brown rot fungus of *Neolentinus lepideus Fr. (*NL)
Paradiso *et al.* [86]	Fungi	*Valsa Mali*
Kargioğlu *et al.* [87]	Parasites	*Sacroptes scabei*

3.5. Parasiticide

Cade oil is a tar extracted from *Juniperus oxycedrus* through destructive distillation. It is a thick red-brownish to dark-brownish clear or turbid liquid with a smoky odour [18]. Cade oil has parasiticide properties. During World War II, it was used to treat scabies caused by *Sacroptes scabei.* Tar is used not only for traditional medicine, but also for parasite protection against both endo and ectoparasites [36]. Tar derived from cedar wood is widely used as an antiparasitic agent against intestinal parasites [55].

3.6. Anti-inflammatory

Tar has numerous properties, including anti-inflammatory properties, and is used in medicine [5], [6]. Many studies have been conducted to investigate the anti-inflammatory activity of some wood tars. Birch tar essential oil is highly anti-inflammatory, anti-itch, disinfectant, and drying. Antipruritic and anti-inflammatory properties of pine tar have been shown [21]. Pinaceae tars have a wide range of applications, including anti-inflammatory and antiseptic properties that aid in the healing of wounds and ulcers [16].

Since 1924, soybean tar Glyteer (Gly) has been widely used in Japan as an alternative to coal tar for the treatment of various inflammatory skin diseases. In their study, Takei et al. showed that the antioxidant soybean tar Glyteer (Gly) rescues the downregulated expression of filaggrin (and possibly other barrier proteins) in a Th2-skewed milieu via AhR activation, which may explain some of its empirical anti-inflammatory therapeutic effects [88].

3.7. Antioxidant

According to some experimental results, tar has antioxidant-promoting properties [89]. In comparison to sawdust, the essential oils from *Cedrus atlantica* wood tar have a high antioxidant activity [4]. Mercimek et al stated that the Lebanon Cedar tar, produced from *Cedrus libani* A. Rich, did not exhibit any source of natural antioxidant based on DDPH radical scavenging [90]. In this study, the content of secondary metabolites was low. Investigation on two of Tunisia's most widespread species, *Acacia cyanophylla* and *Pinus halepensis*, showed that both tars have significant antioxidant properties [91].

Takei et al. clearly proved in their study that soybean tar Glyteer (Gly) exhibited potent antioxidant activity by activating nuclear factor-erythroid2-related factor-2 (Nrf2) and downstream antioxidant enzymes such as NAD(P)H: quinone oxidoreductase 1 (Nqo1), which inhibited the generation of reactive oxygen species in keratinocytes treated with tumor necrosis factor-a or benzo[a]pyrene [88].

3.8. Anti-proliferative effect

Coal tar has been used to study the antiproliferative effect of tars. However, it is assumed that all tars, including pine tar, function similarly. Lavker and colleagues found a transient increase in epidermal proliferation during the first two weeks of tar treatment in volunteers with healthy skin, followed by a progressive thinning of the epidermis [92]. Tars appear to act as keratolytic agents, inhibiting excessive proliferation of epidermal cells by suppressing DNA synthesis in hyperplastic skin, which reduces mitotic activity and protein synthesis in the epidermis' basal layer [93], [94]. This promotes keratinization, which is important in skin diseases like psoriasis. [95]

3.9. Anticancer

Along with its selective effects on cancer cells, cedar tar has the potential to be used in the treatment of colon cancer. The metabolite profile of cedar tar is rich in fatty acids (Duprezianene, Himachalene, and Chamigrene), phenolic compounds (mostly Coumarin, p-coumaric acid, vanillic acid, and tr-Ferulic acid, etc), and organic acids (mainly 3-oh propanoic acid, 2-oh butyric acid and 3-oh isovaleric acid etc.). In colon cancer cells, cedar tar increases ROS production [96].

3.10. Insecticidal

The louse, or *Pediculus humanus capitis*, is a parasitic insect found on the head, eyebrows and eyelashes. And it lives near the human scalp [97]. Tar treatment caused oxidative and morphological damage in insects. Wood tar may be an effective insecticide against the head Lice *Pediculus humanus capitis* [98]. According to Derbali et al., the tar extract from Acacia cyanophylla is significantly more effective as an insecticide against Aphis spiraecola than the tar extract from Pinus halepensis [91]. Tar derived from cedar wood is widely used as an insect repellent [55]. Bamboo tar is a potent botanical aphidicide [99].

4. Toxicology of wood tar

4.1. Toxicity

The acute toxicity of tar, particularly wood tar, has been linked to the presence of phenol and polycyclic aromatic hydrocarbons (PAHs). Pardo *et al* separated wood tar material from pyrolysis into two major subfractions: water-soluble and organic-soluble fractions [100]. Both wood tar subfractions are toxic. The water-soluble fraction contains chemicals (such as phenolic compounds) that cause a strong oxidative stress response and allow chemicals to penetrate more easily living cells. More polycyclic aromatic hydrocarbons (PAHs) and oxygenated PAHs were found in the organic-soluble fraction, which induced genotoxic processes such as DNA damage. Tar products have acute toxic potential due to phenol content [10]. However, because the phenol content of today's topical pine tar products has been reduced, phenol poisoning is unlikely [10]. At higher temperatures (above 800° C), the tar composition shifts to higher molecular tars as poly aromatic hydrocarbons (PAH), necessitating to limit the temperature of production under 800° C [21]. Furthermore, unlike coal tar, which has been shown to be phototoxic, wood tars such as pine tar have not been linked to photosensitization [94]. Modern pine tar is manufactured with higher purity to eliminate toxic phenol and carcinogenic components that were previously a source of concern [21].

4.2. Mutagenicity and Carcinogenicity

Polycyclic aromatic hydrocarbons, which are genotoxic carcinogens, are found in wood tar and wood tar preparations. Wood tar preparations have been shown to cause both benign and malignant skin tumours in mice skin, as well as to form DNA adducts in human skin. Animal carcinogenicity studies have revealed that tars' carcinogenic potential is linked to the polycyclic aromatic hydrocarbon (PAH) fraction [10], [101]. Occupational studies have shown that tar is carcinogenic; however, epidemiologic studies have not confirmed similar results when used topically [22]. The active ingredient in the majority of reports demonstrating the negative effects of tars [102]. Tars differ in chemical composition due to different manufacturing techniques, and as a result, toxicological studies diverge [10]. As a consequence, it is widely used in the dermatological field [103].

4.3. Reactions allergic

Irritant reactions to tar can occur as well. Their use has been linked to an increased risk of irritation and allergic sensitization [104], [105]. Tar can also produce pruritus, folliculitis, comedones, acneiform eruptions, keratoses (tar warts), and keratoacanthomas [106]. Tar allergies are uncommon, but wood tars appear to be more likely than coal tar to cause irritation and sensitization [21].

4.3.1. Ecotoxicology

Hawrot-Paw *et al* concluded that the presence of a mixture of tar and engine oil had a negative effect [53]. The height of the aboveground parts and the length of the roots of spring barley decreased as the dose increased, regardless of the type of pollution. The presence of a mixture of tar and engine oil had a greater negative impact on the reactions of most microorganisms and plants than just tar alone. In terms of the impact of tar on aquatic organisms, Hagner *et al* concluded that even if a wide range of aquatic organisms are sensitive to birch tar oil, it does not pose a serious threat to aquatic biota [6]. Plant essential oils have also been shown to be environmentally friendly.

4.4. Application of wood tar

Wood tar is used in a variety of applications. Wood tar may be a potential chemical preservative of wood due to its chemical composition. For a long time, it has been known that wood pyrolysis products, such as tar, can be used to protect the wood [34]. Tar is used for the protection of waterproofing [31], [107], [108], decoration [31], [109], and adhesion of objects [35], [110]. Furthermore, tar can be used in both human and veterinary medicines [90], it has long been used to treat dermal diseases [111]. It is widely used in the production of tarred ropes and twine, as well as in the impregnation of hemp fiber for oakum. In metallurgy, distillates of pine-wood tar, particularly the creosote fraction, are used in froth flotation processes [37]. Wood tar had numerous applications, including providing a universal source of grease and glue, as well as insulation for building and ship hulls [7]. Tar is also used to treat internal and external parasites. Villagers also use it to remove flies and ticks from sheep and goats. Locals make a tar and rock salt mixture that is placed next to animals' water pans and consumed by the animals to protect the digestive system from endoparasites [36]. In particular, tar derived from cedar wood is widely used in veterinary medicine to protect against intestinal parasites and to repel insects and snakes [55]. As an antiseptic, the insoluble tar is useful in veterinary medicine. Stockholm tar is the name given to tar made from softwood distillation. Its recovery from the condensate is simple. Complex chemical processes can separate aromatic substances from this tar that are useful in medicine and perfumery. If this tar were generated in the developing world, it would most likely find a market in the developing world at a reasonable price [112].

Tar is used to treat foot-and-mouth disease and viral infections in animals. Locals apply it to the mouth sores of sheep and goats [36]. Tar can also be used to treat ulcers. For ulcers, water containing drops of tar is drunk before meals, and the treatment is completed after 5 sessions [113], [114], [115], [116]. Locals have used tar to treat skin diseases such as eczema, acne, alopecia, and fungus. The most common uses mentioned by Moroccan herbalists and [113], [114], [115], [116] producers were for various hair and skin problems such as dandruff, eczema, itchiness, and skin infections [18]. Cedar tar is widely used as an antiseptic in veterinary medicine, as well as in some human health care applications such as ulcers, dandruff, and eczema [55], [117]. Wood tar is used for skin protection as well as traditional medicines [7]. Tar has traditionally been used to aid in the inhalation of asthma patients, particularly in Marrakesh, as well as to prevent, cure, and heal some human diseases such as eczema, dandruff, and ulcers. There are also veterinary applications such as insect and snake repellent, antiseptic for wounds and scratches, and intestinal parasite cure [55].

Norway tar used in pharmacy, Landes tar. Norway tar is derived from two pine species: *Pinus sylvestris and Pinus ledebourii,* whereas Landes tar is derived from *Pinus maritima* [118]. Pine tar was first used in the coating and caulking of boat hulls. It is then noted for its healing properties, leading to its use in the treatment of itching and scabies [11]. There are also pine tar-based veterinary drugs with a wide range of indications. Thus, “Réducine Absorbent” is an external paste used to treat pain, limb engorgement, and "lameness" in horses, mares, and foals. Other products for horse horn and hoof healing include “Onguent Noir Biototal” and “Argiletz Horse Onguent de Pieds” [118]. It is obtained from the beech, *Fagus sylvatica*, and is also known as "beech tar." Its composition differs greatly from that of resinous tars. Beech tar has the potential to convert a portion of parakeratosis (an important phenomenon in people with psoriasis) into orthokeratosis (an increase in orthokeratosis of up to 19%) and reduce blood influx to psoriatic lesions [119].

4.5. Dermatology use

Since ancient times, medicinal tar has been used to treat dermatological conditions [103]. Tar, a traditional treatment, can be used to treat a variety of skin conditions, including psoriasis, atopic dermatitis, and seborrheic dermatitis. Tar is still the first-line treatment in many countries due to its availability and cost savings. Tar formulations are an effective topical therapy for the treatment of inflammatory skin diseases [120]. It contains a pharmacologic substance that has shown significant efficacy in the treatment of psoriasis, atopic dermatitis, and seborrheic dermatitis. Wood tars have no photosensitizing properties and have been used to treat a wide range of cutaneous conditions, including psoriasis and atopic dermatitis [121].

It has a minor use in pharmacy as a component of some ointments and antiseptics [37]. Pine tar is thought to work by inhibiting DNA synthesis and mitotic activity, promoting a return to normal keratinisation. Furthermore, pine tar has been shown to have antipruritic, anti-inflammatory, antibacterial, and antifungal properties [21] .

4.6. Cosmetic use

Natural cosmetics are in higher demand than ever before and are widely regarded as a serious threat to the global economy and society. These new concepts had improved the use of natural extracts as active ingredients in cosmetics, resulting in the reuse of old-style active ingredients derived from natural sources, as well as the development of new green compounds based on sustainable principles [122]. Wood tar is a red-brownish to dark-brownish clear or turbid thick liquid with a smoky odour. In Cosmetics, it is used not only for skin but also for hair care. Cade oil is a tar extracted from *Juniperus oxycedrus* through destructive distillation. It is also used in cosmetics such as soaps and shampoo for its disinfectant properties as well as a perfume [123]. Tar has also been incorporated into shampoos, which are used for seborrheic dermatitis, scalp psoriasis and dandruff. Wood tar shampoo against dandruff: applied to wet hair, it should be left to lather and let it sit for a few minutes [124], [125]. The shampoo is an anti-dandruff to fight against dandruff. The soap also prevents baldness and fights well the alopecia already present. Another shampoo,"Hegor®" Cade Oil Shampoo, is based on Cade Tar. Unlike other shampoos based on cade oil, this shampoo is used when the scalp is dry [80]. Cedar oil is extracted from tar. Due to its less pronounced smell, it is often used instead of cade oil [11].

5. Conclusion

In addition to green herbaceous material, biomass includes waste from forestry, agriculture, and algae. Their ability to use energy in a way that conforms to the concept of balanced development is what gives rise to the term "circular economy". Woody biomass, which is widely used, sustainable, and renewable, has the potential to replace a significant amount of fossil fuels. Smallholders in Sub-Saharan Africa use an earthen kiln to produce charcoal for fuel. In Ivory Coast, the traditional earth mound kiln is used to produce charcoal to meet domestic thermal needs. Traditional kilns emit combustion smoke, which is hazardous to both the environment and human health. Woody biomass, in addition to charcoal, is pyrolyzed to produce non-condensable and condensable gases (pyroligneous acid and tar). This technology is a method of mitigating global climate change that emits no or very little carbon dioxide into the atmosphere. Tar has numerous antimicrobial, antioxidant, anti-inflammatory, insecticidal, anti-proliferative, and anti-cancer properties. It can then be used for skin care. Tar has the potential to increase smallholder income while decreasing environmental pollution. The use of wood tar may result in a cleaner environment and ecological system, as well as increased socioeconomic and health benefits. More research is needed to determine the mechanism underlying its pharmacological properties.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no conflicts of interest relevant to the publication of this paper.

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