1980

Creosote, its Biodegradation and Environmental Effects

David A. Webb
Manager, Creosote Products Development
Industrial Products Division
Koppers Company, Inc.
Monroeville, PA

The pressure treating wood industry is unique with respect to its use of pesticides. The preservative chemicals are not broadcast sprayed or otherwise widely distributed over large areas as occurs with those pesticides applied to field crops, etc. The preservative materials are forced or pressure impregnated into wood inside closed cylinder retorts.

Creosote and its solutions with coal tar and heavy petroleum are the major use preservatives in the pressure treating industry. They have been widely used as a wood preservative for over a century with no evidence of adverse health or environmental effects. Creosote does not concentrate, persist, or occur to levels in man or the environment in amounts that are likely to result in any significant adverse effects. In fact, creosote does not accumulate because, at low concentrations, it is readily biodegraded.

Before citing specific evidence of creosote's biodegradations, it is important to define the significance of creosote to the pressure treating industry, along with its use patterns.

Creosote, creosote-coal tar, and creosote-petroleum are used primarily in the wood preservation of timber products in the commercial industries of railroads, utilities, construction, and agriculture. Of all the creosote wood products treated, application is by pressure methods in 99 percent of all the creosote treated wood, while less than 1 percent is applied with nonpressure methods. The demand for creosote has been relatively constant; it has been shown over the past few years to be a mature market. According to the 1978 statistics (2), the consumption of straight creosote, creosote-coal tar, and creosote-petroleum solutions in 1978 was 34, 66, and 14 million gallons, respectively, for a total of 114 million gallons, which resulted in the treatment of approximately 142 million cubic feet of creosoted wood products. When compared with the total of 283 million cubic feet of wood treated in 1978, creosoted treated wood represents 50 percent of the total. Creosote is thus still the major use wood preservative, and is extremely important to the pressure treating industry.

The treatment of crossties uses the largest amount of creosote of all wood products treated with this preservative. It is mixed with coal tar or heavy petroleum in the majority of all instances when used for treating the crossties. In 1978, approximately 27.8 million crossties were treated with creosote and its solutions.

Wood utility poles are treated primarily with the straight creosote distillate. About 1,138,000 poles were treated with creosote. This number represents approximately 31 percent of all treated utility poles, the remainder being treated with other preservatives.

The construction industry uses several creosote treated wood products, including lumber, timbers, piling—both marine and foundation—block flooring, poles, and posts. Approximately, 24.8 million cubic feet of wood were treated with creosote and its solutions for use in the construction industry during 1978.

With respect to the agricultural market, over 2.9 million posts were treated with creosote preservatives in 1978. About 26.3 percent of the fence posts were given preservative treatment with creosote.

The following table shows the individual creosote treated wood products with their respective total production and share of the market during 1978 (2).

	Creosote Treated Cubic Feet (Million)	% Treated with Creosote
Crossties and Switch Ties	98.8	99
Pole, utility and construction	17.4	28
Piling, marine and foundation	8.7	89
Lumber and Timbers	10.7	12
Fence Posts	2.9	26
Crossarms	0.1	1
Other	3.5	26
Total	142	50

Creosote and the Environment

As can be readily observed by the product end use and types of creosoted wood being produced by the treating industry, the preservative is pressure impregnated into the wood to stay in the wood in order to provide protection to it from fungi and termite attack. In this particular case, with creosote, as well as with the other preservative chemicals, they are not broadcast sprayed or widely distributed.

Creosote and its solutions do not bio-accumulate despite the long record of use—over 100 years. There is no evidence to indicate that there is any significant impact of creosote preservatives on the food chain. In fact, the amount of creosote as either a liquid or vapor that enters the environment is relatively small. Estimated discharge per year from all wood preserving plants using creosote in the United States totals nine pounds of phenolic compounds and 68 pounds of "oil and grease." Considering that creosote and its solutions have had approximately one billion pounds per year usage in the United States over the past several years, the small loss of creosote indicates the excellent handling and use practices currently being employed by the wood preserving industry.

During handling, storage, and installation of any creosote treated wood product, there may be minimal inhalation of volatiles. However, after the creosote treated wood products have been installed, the incidence of contact with humans, wildlife, or domestic animals is also minimal. The treated wood is used predominantly outdoors and is partly or wholly buried in soil or submerged in water. Test data indicated creosote treated wood in direct contact with the soil and/or water after many years of service has, for all practical purposes, about the same preservative retention as it originally received during treatment.

Biodegradation of Creosote

Available data shows that components of creosote are biodegraded. Thompson and Dust (13) monitored total phenol content of water taken at several soil depths after irrigation of land with untreated creosote wastewater* applied at the rate of 3,500 gallons/acre/day. The biodegradation, removal, of phenols equaled or exceeded 99 percent at all soil depths sampled in the range of one to four feet. Fisher and Tallon reported similar results at this Association's Annual Meeting in Miami in 1971 (10).

As cited by Arsenault in the two-volume textbook on wood preservation by Nicholas (1), not too much was known about the microbiological attack on creosote in soil. There has been, however, considerable evidence cited to show degradation by soil bacteria and fungi on crude oils, petroleum, bitumen, asphalt, and other aromatic hydrocarbons. Thus, creosote and its solutions with coal tar and petroleum are basically aromatic hydrocarbons of the polynuclear (PNA) variety, it follows that one can conclude biodegradation for creosote materials.

Specifically, a Mississippi State University study (14) on movement of preservative from treated poles indicated that none of the major components of creosote were isolated from soil samples taken to a depth of six inches within the range of 2 to 24 inches from the treated pole. It was assumed that those creosote components either did not or if the components did migrate into the soil during the five-year duration of the study were biodegraded by soil micro-organisms.

Work in the laboratory by Drisko and O'Neill (8) and O'Neill et al. (12) has shown several types of bacteria biodegrade creosote. One species, Pseudomonas creosotensis, has been found to be geographically widespread throughout the world, ranging from marine water harbors in the northern latitudes of Alaska to the tropical southern climates of Central America and reaching westward to the south Pacific islands.

Colwell et al. (6) have reported on the sampling and collection of hetertropic bacteria involved in the degradation of aromatic hydrocarbon found on the surface of creosote treated piling. The evidence indicates degradation by the bacteria of certain creosote components such as naphthalene. Colwell's work with the creosote piling installed at the Roosevelt Roads Naval Base, Puerto Rico concludes that there was no bio-accumulation of creosote in the immediate environment surrounding the creosote treated pile. Thus, the creosote was not available to be "taken up" by larger organisms, such as certain types of shell fish which ultimately could become a part of the food chain.

Creosote Loss from Treated Wood

Now that it has been established from available data that creosote is biodegradable, let's take a look at what happens to creosote treated wood in the environment. Losses of creosote and its solutions from treated wood are not considered to be significant. The minimal loss that does occur may take the form of a liquid (whole creosote) or vapor (lighter fraction of the creosote). The migration of the whole creosote takes the form of an exudate. It is also important to note that the major components of creosote are not soluble in water. Generally, the phenol compounds make up less than five per-

* This discharge will generally be less than 100 ppm. In fact, EPA recent guidelines set this concentration as the maximum.

cent of the total creosote (a standard AWPA material distilled from high temperature coal tar). Thus, a small fraction of the creosote is subject to the leaching effects of water.

With respect to marine and fresh water exposure of creosote treated wood, it is important to remember that the surface to volume ratio is significantly different for a test panel (e.g. 1"x4"x12") than for a large pile (e.g. one-foot diameter butt, 40 ft. in length). Thus, the loss of creosote preservative from small panel is proportionately greater than for a large pile due to the exposed surface area when compared to its respective volume. One must give this fact consideration when analyzing test data for creosote migration losses.

Crossties, lumber and timbers, poles and piling, when properly treated with creosote, are expected to provide an average service life of between 30 to 50 years, varying according to service conditions. Creosote loss, either liquid or vapor, from the treated wood into the environment is a relatively slow process. Howe and Koch (11) stated that there are one billion crossties currently in service in the United States. These crossties are treated with creosote-coal tar solutions for installation often east of the Mississippi River or creosote-petroleum solutions for use generally west of the Mississippi. The approximate amount of these creosote solutions in the crosstie would be 30 billion pounds. It does seem reasonable to conclude that with these quantities of creosote solution in use, evidence of adverse health and environmental effects would have occurred long ago. But, in fact, the reverse is true, there have been no serious problems.

Von Rumker et al. (15) basically agreed with the above, stating essentially that the available evidence shows the environmental problems of creosote are minimal. Reports of several researchers were referenced that indicate the preservative retention in creosote treated materials did not change significantly during service life of up to 40 years. Vaporization of creosote compounds (polycyclic aromatic compounds) from treated wood was compared by Von Rumker to emission of similar type compounds, but in greater quantities, to our evergreen forest—pine species in the south and northeast; Douglas-fir and pine timbers of the Pacific northwest.

Marine Environment

There is some movement of creosote from treated wood in the marine environment. However, there are data which show this migration to be minimal. Baechler and Alpen (3) reported creosote retentions of between 18 to 25 pcf in Douglas-fir piling after 25 years in service. An earlier study by Baechler and Roth (1) cited creosote retentions of 19 to 20 pcf in piling installed in 1900 and then removed after 59 years. Bramhall and Cooper (5) reported creosote retentions averaging about 15 pcf for Douglas-fir piling after 40 years.

Each of these three separate reports have one theme in common with respect to creosote and its environmental effects. There was minimal loss of creosote from the treated piling over an extended period of time—25 to 59 years. This can be established by the high levels of creosote retention found after the long periods of service.

This retention data and minimal creosote movement. coupled with the work cited on the biodegradability of creosote, clearly illustrates that no environmental hazard can be established for creosote treated wood products.

There has been only one literature reference which indicates that creosote was found to be a pollutant. Dunn and Stich (9) measured the benzo(a)pyrene content of mussels attached to a creosoted wharf and attributed the BaP content of the mussels to creosote contamination. However, this is an unreliable assumption, because exhausts from gasoline and diesel-powered boats are a significant and continuing source of BaP and other polynuclear aromatics, particularly in a dock or wharf area where boat traffic is likely to be heavy and engines are operating in the inefficient idling mode. Exhausts usually discharge at or near the water surface along with engine cooling water, also containing BaP. Because of their failure to take this important source of BaP contamination into consideration, Dunn and Stich's conclusions regarding migration of creosote into the marine environment and possible bioaccumulation in mussels must be rejected (7).

Conclusions

Creosote and its solutions with coal tar and petroleum have given excellent service for over 100 years in protecting wood from the attack by fungi, termites, and marine boring organisms. These creosote preservatives are pressure impregnated into the wood to stay in the wood. Available evidence indicates that once in the wood the creosote does not migrate or move from the wood in any significant quantities. When creosote does move out into the soil from the wood as either a liquid or vapor is readily biodegraded. Creosote treated piling for use in both fresh water and salt water marine applications has been known to leave an oil sheen on the water surface for a short period after driving. This very thin film (nonograms) of creosote is easily oxidized and biodegraded; thus, dissipating within a few days after installation. There is no evidence to suggest that there is harm to the environment.

Thus, it must be concluded that creosote treated wood products do not contaminate or harm the environment, and they do not enter the food chain for eventual wildlife and human consumption. Because there are no known harmful effects from creosote treated wood, this treated product can continue to be used without any significant effect in the environment. The proper and continued use of creosote as a preservative to extend the life of treated products many times over benefits the users of treated wood and helps to conserve timber—a valuable renewable resource.

Literature Citations

1. Arsenault, R. D. Vol. II edited by D. D. Nicholas. 1973. Wood Deterioration and Its Prevention by Preservative Treatments, Syracuse University Press.
2. American Wood-Preservers' Association. 1978. wood Preservation Statistics.
3. Baechler, R. H. and R. M. Alpen. 1964. Extraction of Borings Removed from Fender Piles in San Francisco–Oakland Bay Bridge. AWPA Proceedings 60:32–37.
4. Baechler, R. H. and H. G. Roth. 1961. Further Data on the Extraction of Creosote from Marine Piles. AWPA Proceedings 57:120–132.
5. Bramhall, G. B. and P. A. Cooper. 1972. Quality Comparison of Current Marine Piling with 25 or 40 Year Service Piling. AWPA Proceedings 68:194–202.
6. Colwell, R. R. et al. 1979. Microbial Ecology Studies of Biofouling of Treated and Untreated Wood Pilings in the Marine Environment. Report by the University of Maryland to the Office of Naval Research.
7. Detrick, R. S. 1979. "Coal Tar, Creosote, and Coal Tar Neutral Oil," Discussion and Comments. Submitted as part of American Wood Preservers Institute comments to Environmental Protection Agency. Library of Congress Catalog Card No. 79–52018.
8. Drisko, R. W. and T. B. O'Neill. 1966. Microbiological Metabolism of Creosote. Forest Products Journal 16(7):31–34.
9. Dunn, B. P. and H. F. Stich. 1975. The Use of Mussels in Estimating Benzo[a]pyrene Contamination of Marine Environment. Proceedings of the Society of Experimental Biology and Medicine 150:49–51.
10. Fisher, C. W. and G. R. Tallon. 1971. Wood Preserving Plants' Wastewater Problems—Some Solutions. AWPA Proceedings 67:92–96.
11. Howe, J. P. and P. Koch. 1976. Dowel-Laminated Crossties. Forest Products Journal 26(5): 23–30.
12. O'Neill, T. B. et al. 1960. A Creosoted Tolerant Marine Bacterium. U. S. Naval Civil Engineering Laboratory Technical Note N-398.
13. Thompson, W. S. and J. V. Dust. 1973. Pollution Control in the Wood-Preserving Industry. Part IV. Biological Methods of Treating Wastewater. Forest Products Journal 23(9):59–66.
14. United States Department of Agriculture (USDA). 1980. A Report of the USDA-States-EPA Preservative Chemicals RPAR Assessment Team, "Biological Assessment of Pentachlorophenol, Inorganic Arsenicals and Creosote." (Unpublished draft report.)
15. Von Rumker, R. et al. 1975. Case Study No. 20. Creosote. In: Production, Distribution and Environmental Impact Potential of Selected Pesticides. EPA Report No. 540/1–74–001.

Discussion

B. F. Murphy: Mr. Webb, I concur with your presentation. It is informative, however, one question is, do we have direct representation as a member of E.P.A.?

Mr. Webb: Do we, as an industry, have representation?

Mr. Murphy: Yes, direct. You have been referring to the different studies that have been made. Do we have direct representation on the EPA Board?

Mr. Webb: No, because that is not the function of EPA. They have their own people. We have continuing dialect. They come to the Association asking for information.

Mr. Murphy: Well, the dialect can necessitate an interpreter.

Mr. Webb: It is not possible to get direct representation. These are government employees. You can't have representation on these agencies.

Mr. Murphy: Have we tried?

Mr. Webb: It is a government agency.

Mr. Murphy: A captive audience is effectively impressed, informed and influenced by direct presentation. We should try to get direct representation.

Mr. Webb: Your point is well taken, Ben, we have been going with printed material. Also, we have made visual presentations of what our industry is all about.

Gunther Becker: Dr. Kerner-Gang, my colleague of the Federal Institute for Testing Materials in Berlin, has begun to show that the phenolic substances of creosote can be biodegraded by bacteria rather easy. However, if you have a good composition of the creosote, with high boiling substances and sufficient quantity injected into the wood, we could demonstrate that with the very susceptible beech timber for instance, in Western Africa, in Liberia for ten years and more, we got an excellent performance of treated sleepers under tropical conditions against fungi and termites. It depends upon the composition and the quantity. Creosote is an excellent wood preservative in spite of the possibility of breakdown by the low boiling substances by bacteria.

MR. WEBB: I agree with you 100 percent, Gunther. In no way are we talking about whether or not creosote is a viable wood preservative. We are just talking in terms of its environmental effects and we are talking about low concentrations.

R. D. GRAHAM: Creosote and the Bethel process of the early 1800's laid the foundation for the wood preservation industry of today. Both remain important to our successful preservative treatment of wood. Like wood, we take creosote so much for granted that we fail to recognize its importance until a paper, such as this, opens our eyes. Dave has made a strong case for the continued use of creosote which will be difficult to refute.

I am confident that creosote will remain one of the industries' most versatile preservatives for protecting wood under the harshest environments on land or in the sea. Research will make it even more versatile.

As Dave knows, we are especially interested in finding out why properly creosote-treated piles are attacked by *Limnoria tripunctata* along the California Coast but seldom or not at all in upper Oregon estuaries heavily populated by this crustacean. Untreated Douglas-fir piles are destroyed within eight years and pressure-creosoted piles as well as timbers are hollowed out because of the use of pointed tongs and of fasteners below water. Dr. Jeff Gonor, Oregon State University Marine Science Center, found *L. tripunctata* from Los Angeles Harbor and Oregon estuaries to be similar morphologically. He is now conducting studies to determine if physiological differences exist, and plans to look for genealogical differences. Such research could provide a basis for improving the effectiveness of creosote against this tiny wood destroyer.

HARRY HOCHMAN: I am glad to see that a representative of the creosote industry has finally agreed that creosote is biodegradable. It took a long time. In 1962, Drs. Drisko, O'Neill and I reported, in a Naval Civil Engineering Laboratory report, on the attack of marine microorganisms on creosote and several of its constituents. Dr. O'Neill actually isolated a new bacterium that was especially able to metabolize creosote constituents.

This report summarizes several studies that tend to show that the major amounts of creosote impregnated into the wood is still there after many years of marine exposure. This is undoubtedly true but of little significance because marine boring organisms attack the surface of the wood only. It is here that significant amounts of creosote is lost by biodegradation and oxidation. The presence of large quantities of toxic creosote in the interior of the wood has little protective value when the surface "creosote" is so changed that the borers can swim in it with impunity.

The biodegradation of thin films of creosote such as on a creosote slick should recede rapidly and possibly completely.

N. BURGERS: I hear you talking about tar acids and this subject is also dealt with in a harmonization project for the specification of creosote in W. Europe, on which we are working in the Western European Institute for Woodpreservation. We try to get down to two (max. three) types of oil. One of the main points is the restriction of the tar acids to maximum three percent (at 355°C). Up to now it was "at least" three percent so this is quite an improvement. One of the main reasons for this is that environmental and health authorities try to ban or restrict the use of creosote on the argument that it could be dangerous.

SESSION CHAIRMAN COONEY: Thank you very much, Dave.

For the past few years we have been most fortunate to have with us the President of the Railway Tie Association. It is my privilege and pleasure to introduce Mr. W. L. Martinell, RTA President, who will address our meeting. Bill.