The Contribution of Tobacco Constituents to Phenol Yield of Cigarettes[1]

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Phenol has been determined as a component of cigarette smoke for many years (2, 4, 5, 6, 8, 9), but until recently no studies have appeared on the origin of phenol with respect to specific tobacco constituents, although some investigators have speculated in this area.

It would appear possible to study the conversion of tobacco constituents during the smoking process by enriching or depleting tobacco with respect to a certain constituent. However, this introduces a number of variables which are difficult, if not impossible, to control. Addition of significant amounts of material—five to ten percent by weight—is usually necessary to bring about demonstrable changes in smoke composition, and, undoubtedly, the burning characteristics of the tobacco are changed. Extraction of tobacco with solvents to deplete certain constituents produces similar alterations in the burning process.

The pyrolytic technique has been used by several investigators to simulate the burning characteristics of tobacco constituents and to study the yield of smoke components (3, 10), but only one investigation has dealt directly with the precursors of phenols in tobacco smoke (1). Pyrolysis experiments are convenient to study the thermal conversions to tobacco constituents, but unless the conditions which exist in the burning cigarette during a specific conversion can be approximated, pyrolytic studies may be misleading. Moreover, when individual compounds are pyrolyzed, the absence of other tobacco components cannot be neglected in reaching conclusions, since they may produce catalytic effects.

The addition of C^{14} labeled compounds to tobacco appears to offer the most unequivocal technique for studying the contribution of precursors to smoke constituents. The labeled compounds can be added to tobacco in extremely small quantities, and no difficulty is experienced in obtaining cigarettes with normal burning characteristics.

In this investigation of phenol precursors the pyrolytic method was adopted to develop preliminary conclusions, and then the tracer technique used to substantiate or refute these conclusions.

Experimental Methods

A. Pyrolytic

The pyrolysis apparatus shown in **Figure 1** consisted of a 100 cm x 2.5 cm Vycor tube packed to about 60 cm with Vycor chips. The packed end of the tube was heated independently of the sample end by two standard combustion furnaces. The sample was placed in a Pyrex tube with an external diameter slightly less than the internal diameter of the combustion tube and located about 15 cm from the Vycor packing. A third furnace was driven mechanically over the sample toward the fixed furnaces. Air or nitrogen was passed through the combustion tube at a fixed rate. All temperatures were controlled within 3°C. The trapping system consisted of a conventional cold trap submerged in a dry ice-acetone slurry. Phenol analyses were carried out by the method described by Spears (9), except the steam distillation was omitted. The relative standard deviation of the pyrolytic procedure was found to be 10%.

B. Tracer

The radioactivity was measured by liquid scintillation counting. All samples were placed in 13 to 17 ml of the scintillating solution composed of toluene containing 6 g/liter 2,5-diphenyloxazole and 0.10 g/liter 1,4-bis(2-[5-phenyloxazolyl])-benzene and counted at 0°C. Quenching was determined by the method described by Ross (7).

Approximately four grams of tobacco were treated with 50 ml of an ethanol-water solution containing 5.12×10^5 cpm/ml of uniformly labeled glucose [specific activity 200 mc/mM]. After thorough mixing, the solvent was evaporated on a rotating evaporator and then lyophilized to ensure that all solvent was removed. The dried tobacco was removed from the flask and the flask washed several times with the ethanol-water solution. These washings were combined with the trapped solvent evaporated from the tobacco and the radioactivity measured. By subtracting this value from the counts

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