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## Characterization of *N*-Ethyl-1-Phenylcyclohexylamine Reaction Components

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**REFERENCE:** Kreffft, R. H., Masumoto, S. S., and Caldwell, T. V., "Characterization of *N*-Ethyl-1-Phenylcyclohexylamine Reaction Components," *Journal of Forensic Sciences*, JFSCA, Vol. 34, No. 5, Sept. 1989, pp. 1266-1279.

**ABSTRACT:** Impurities found in the two principal methods of the manufacture of *N*-ethyl-1-phenylcyclohexylamine (cyclohexamine, PCE) are identified. Identification of *N*-ethylcyclohexanecarbonitrile allows the forensic science analyst to determine the specific synthesis route.

**KEYWORDS:** toxicology, *N*-ethyl-1-phenylcyclohexylamine

The Schedule I controlled substance *N*-ethyl-1-phenylcyclohexylamine (PCE or cyclohexamine) [1] manufactured in clandestine laboratories is commonly contaminated with starting materials, reaction intermediates, and by-products. This paper presents analytical data for the two principal methods of synthesis of the title compound. For one of these syntheses, the identification of a reaction intermediate allows the analyst to identify the method.

### Synthetic Routes

Figure 1 illustrates the two principal methods of synthesis [2,3]. Reaction A is a modification of the original patent (Parke, Davis and Company, 1963) which used anhydrous ethylamine, cyclohexanone, and solid potassium hydroxide to make *N*-cyclohexylidenethylamine [4]. This intermediate is unstable and will decompose rapidly in the presence of water. The later simplifying modification using petroleum ether, in which the intermediate is soluble, allows aqueous ethylamine (70% in water) to be used [2].

The intermediate from Reaction B, *N*-ethylcyclohexanecarbonitrile, is very stable and has been stored for years with no change.

The organometallic phenylmagnesium bromide, which is used successfully in the synthesis of 1-(1-phenylcyclohexyl)piperidine (PCP or phencyclidine), may not be a suitable substitute for phenyllithium in this reaction [2,3]. At least one other study has shown that substituting phenyllithium for phenylmagnesium bromide does not yield the same product [5]. Phenyllithium can be made from bromobenzene and lithium metal [6,7] or purchased commercially.

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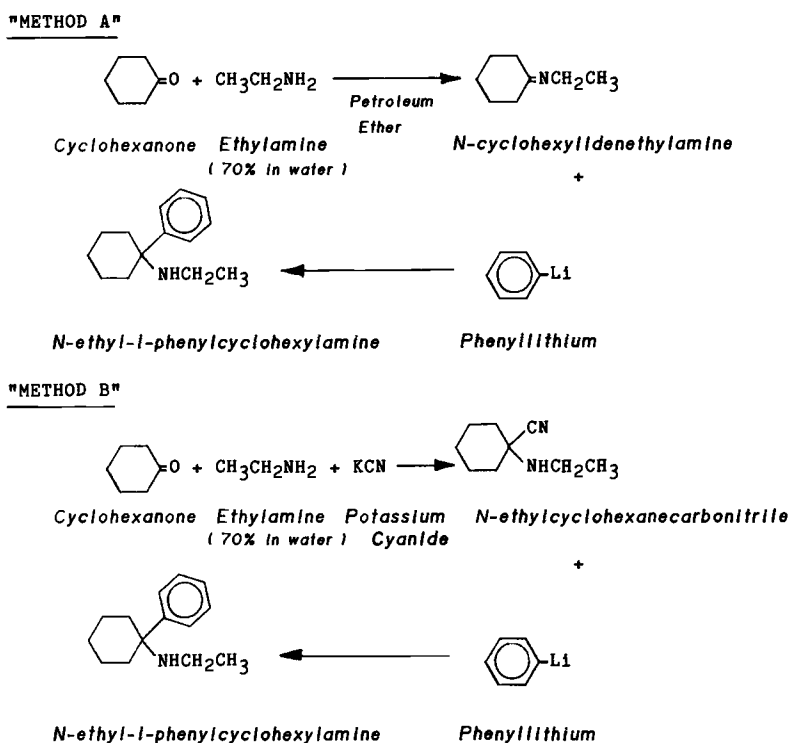


FIG. 1—Two principal methods of synthesis.

### Instrumental Procedure

Proton nuclear magnetic resonance (PNMR) spectroscopic data was obtained using deuterated chloroform with tetramethylsilane as reference, on a Varian EM 390, 90-MHz spectrometer. The PNMR spectra of *N*-cyclohexylidenethylamine, *N*-ethylcyclohexanecarbonitrile, *N*-ethyl-1-phenylcyclohexylamine, and *N*-ethyl-1-phenylcyclohexylamine hydrochloride are shown, respectively (Figs. 2 through 5). Fourier transform infrared (FTIR) spectrophotometric data was obtained from potassium bromide pellets using a Perkin-Elmer 1710.

*N*-ethylcyclohexanecarbonitrile and *N*-ethyl-1-phenylcyclohexylamine, oils at room temperature, were run as thin films on pellets, respectively (Figs. 6 and 7). The FTIR spectrum of *N*-ethyl-1-phenylcyclohexylamine hydrochloride is shown (Fig. 8). Removal of residual cyclohexanone which appeared in some PNMR and FTIR spectra was achieved by using the sodium bisulfite addition technique.<sup>3</sup>

Mass spectral data was obtained from a Hewlett-Packard 5970 mass selective detector interfaced with a Hewlett-Packard 5890 gas chromatograph, containing a 12-m by 0.2-mm inside diameter (id) capillary column with a 0.33- $\mu$ m coating of cross-linked methyl silicone gum. The GC/MS mixed reference standard's total ion chromatogram exhibits nine peaks of interest (Fig. 9). The related mass spectra are shown (Figs. 10 through 18). A temperature program of 50 to 220°C at 10° per minute was used with helium as the carrier gas at 1.5 mL per minute. All of the mass spectral data is normalized, and at the present time, one by-product is unidentified (Fig. 12).

<sup>3</sup>C. Ruybal, DEA South Central Laboratory, Dallas, TX. personal communication, May 1983.

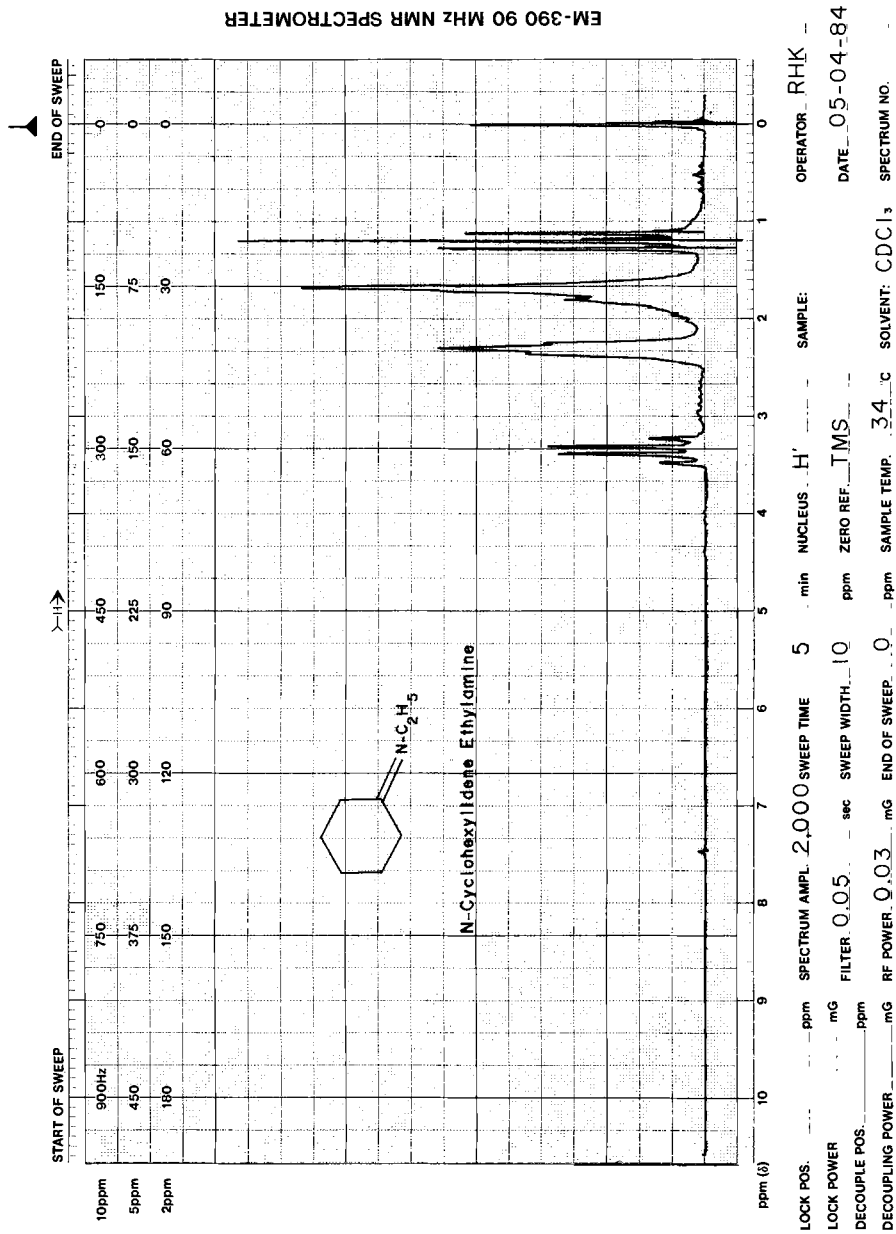


FIG. 2—The *PNMR* spectrum of N-cyclohexylideneethylamine.

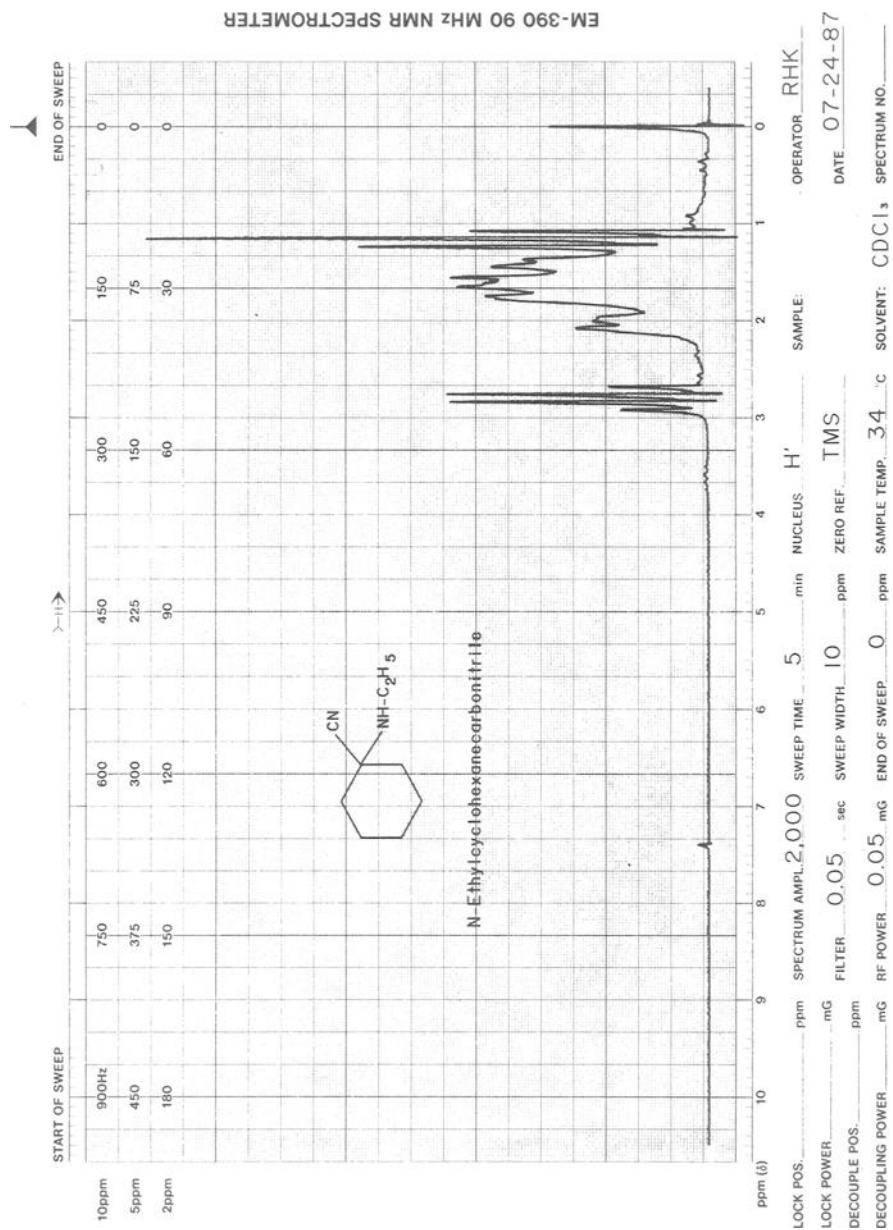


FIG. 3—The PMMR spectrum of N-ethylcyclohexanecarbonitrile.

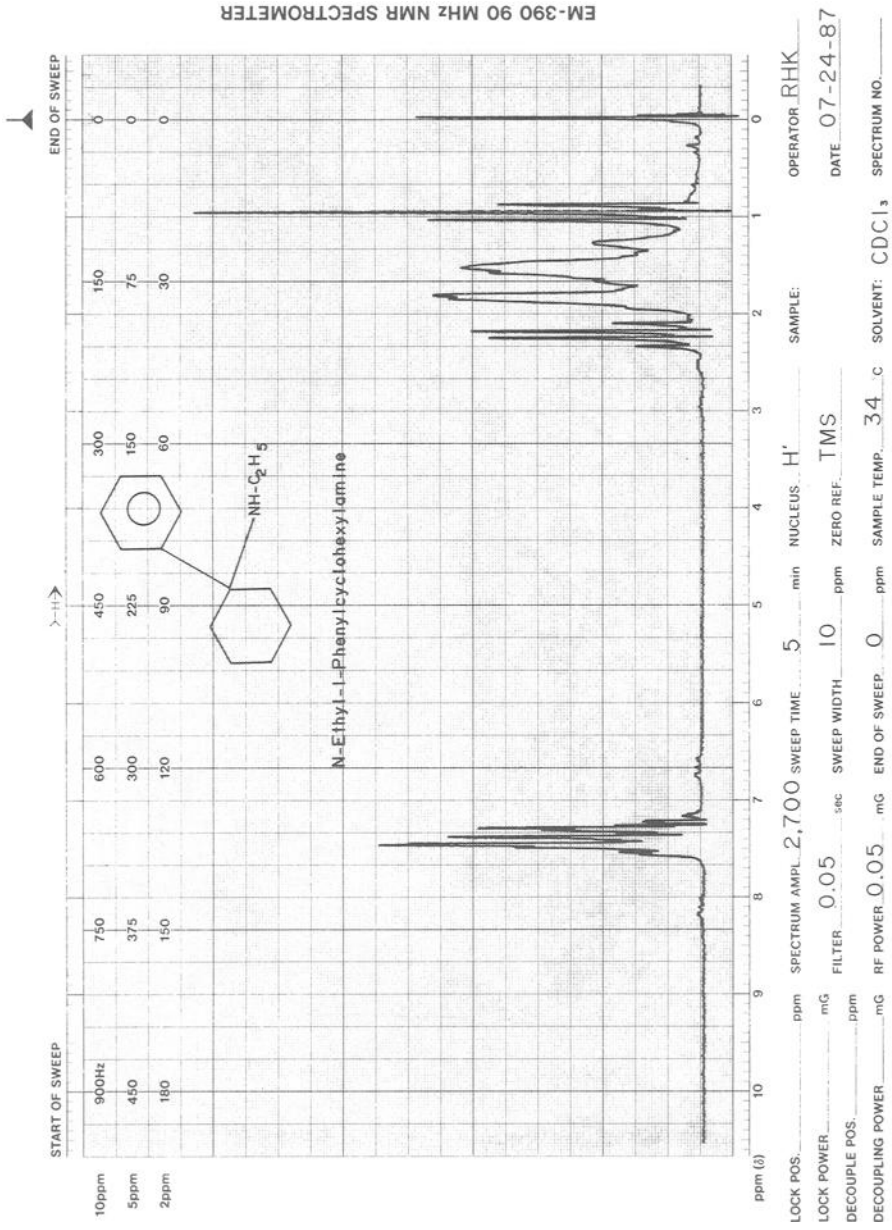


FIG. 4—The *<sup>1</sup>HNMR spectrum of N-ethyl-1-phenylcyclohexylamine.*

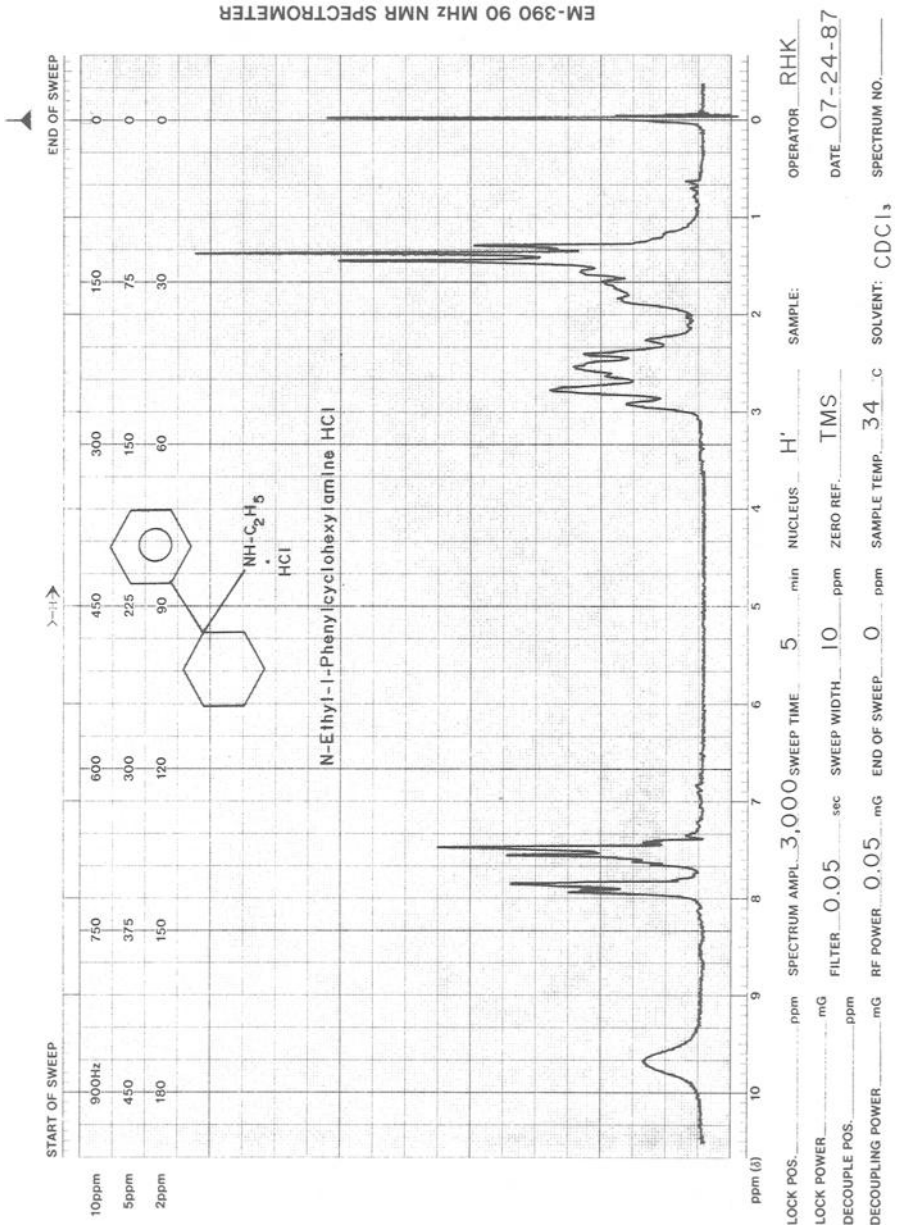


FIG. 5—The PNMR spectrum of N-ethyl-1-phenylcyclohexylamine hydrochloride.

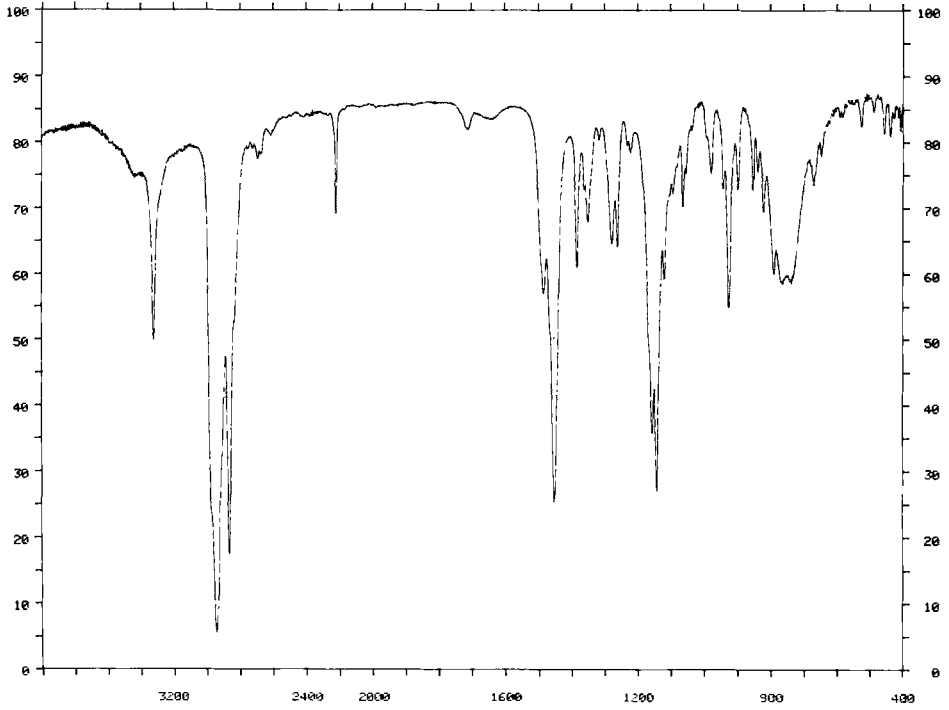


FIG. 6—The FTIR spectrum of N-ethylcyclohexanecarbonitrile.

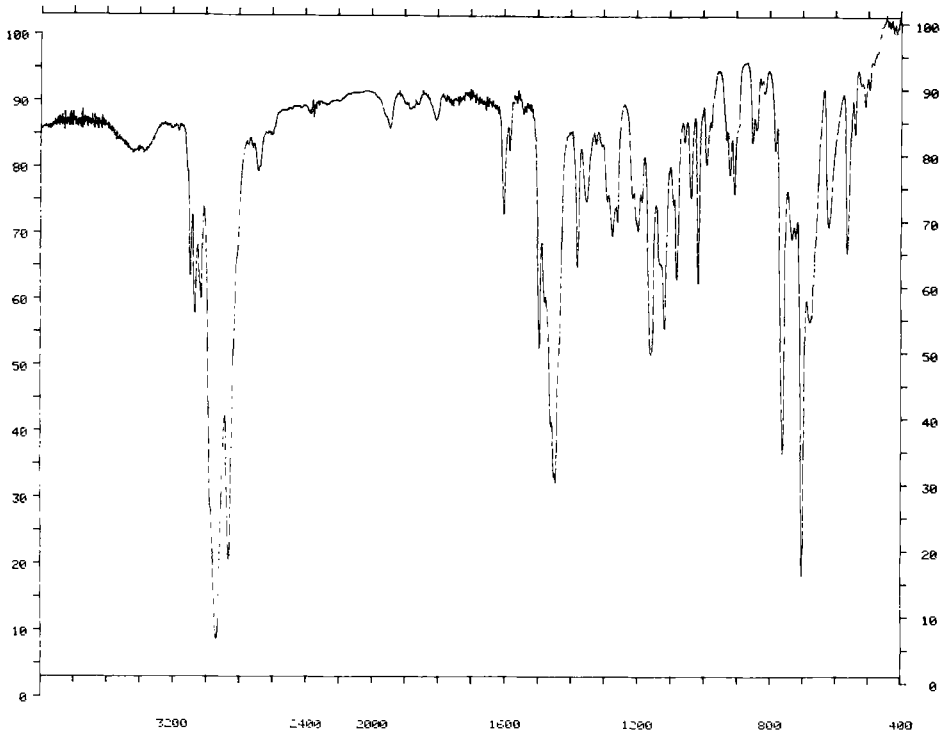


FIG. 7—The FTIR spectrum of N-ethyl-1-phenylcyclohexylamine.

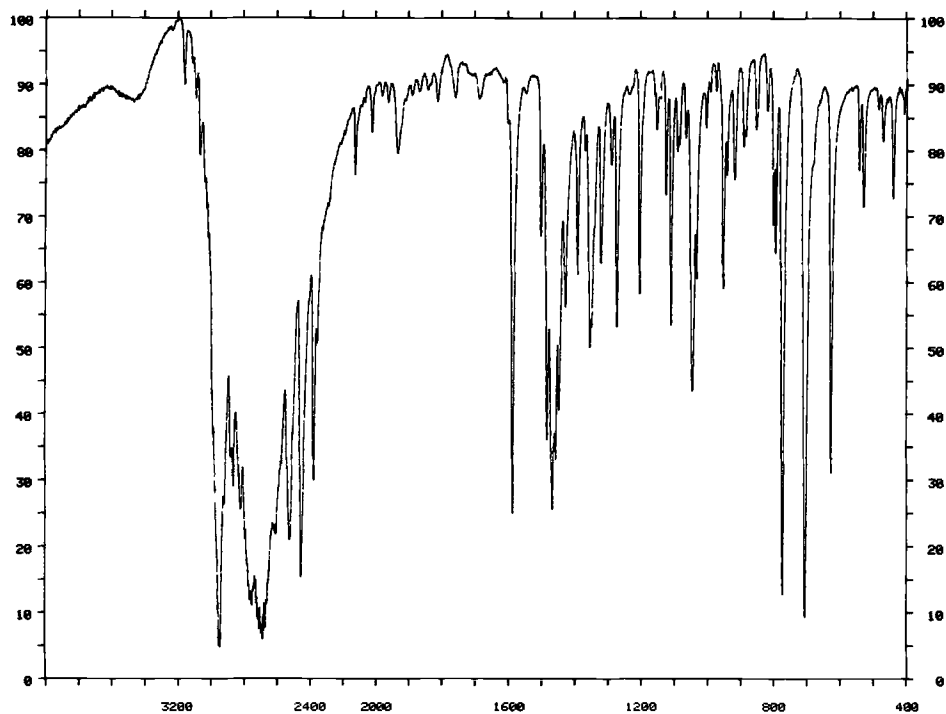


FIG. 8—The FTIR spectrum of N-ethyl-1-phenylcyclohexylamine hydrochloride.

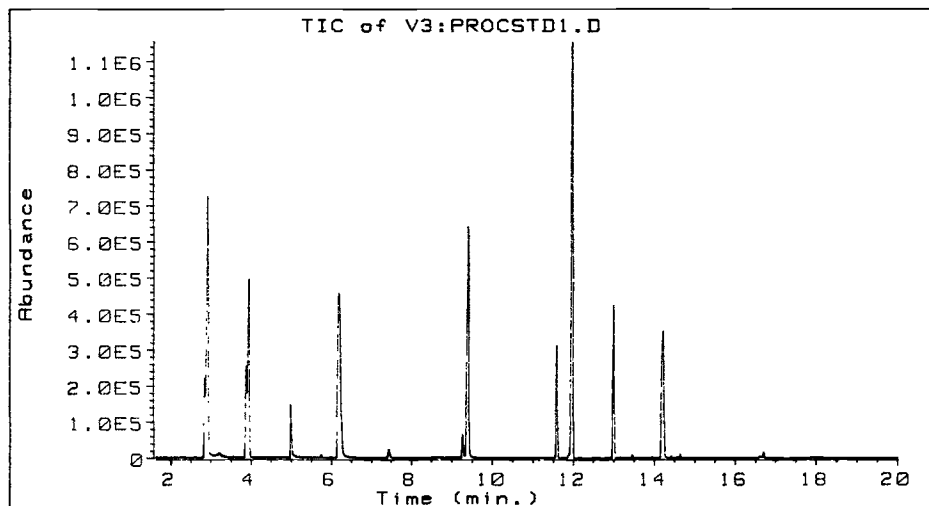


FIG. 9—The GC/MS total ion chromatogram.



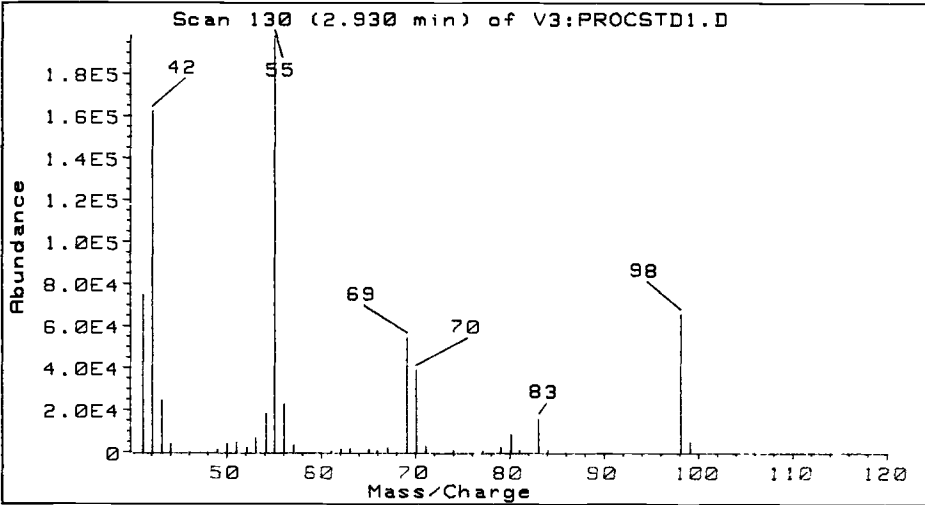


FIG. 10—The mass spectrum of cyclohexanone.

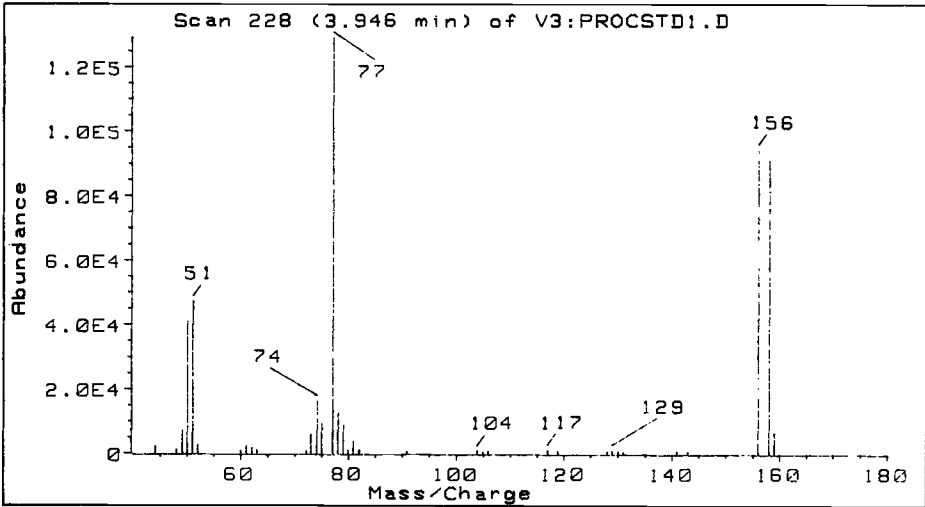


FIG. 11—The mass spectrum of bromobenzene.

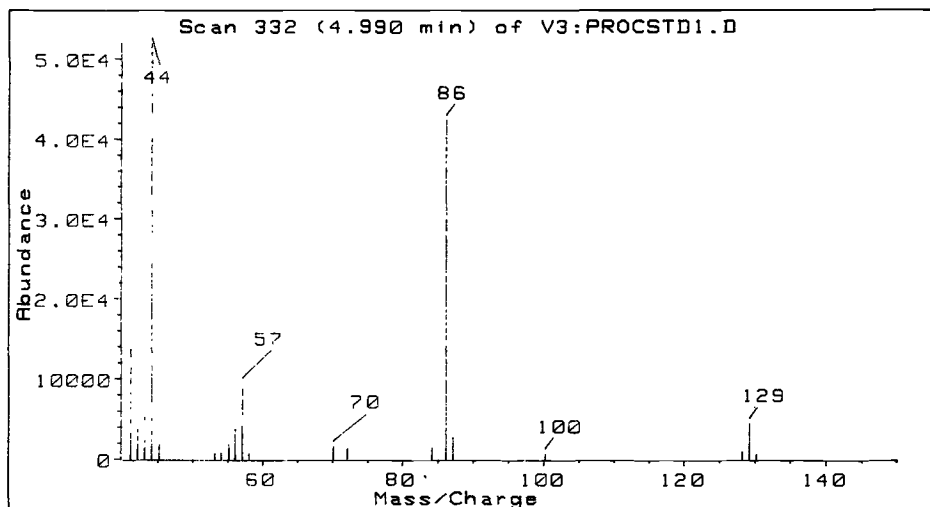


FIG. 12—The mass spectrum of the unidentified GC artifact.

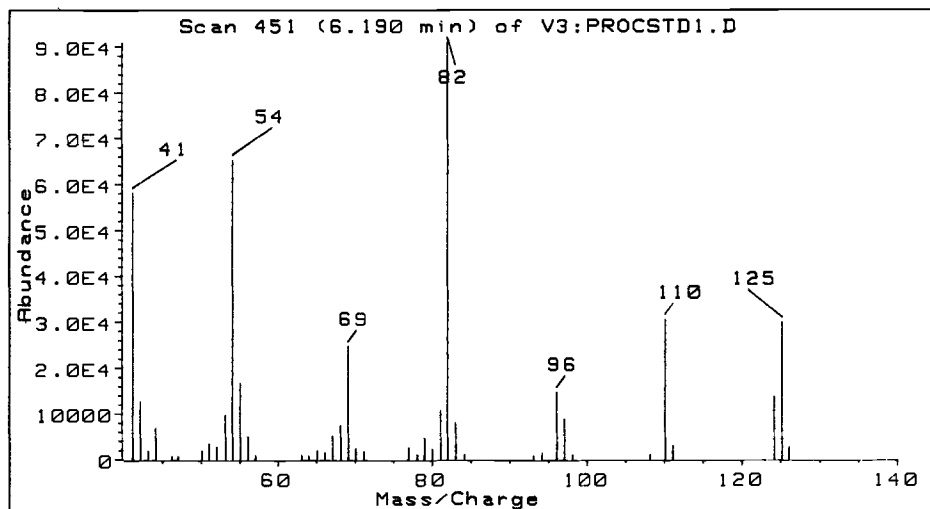


FIG. 13—The mass spectrum of N-cyclohexylidenethylamine.

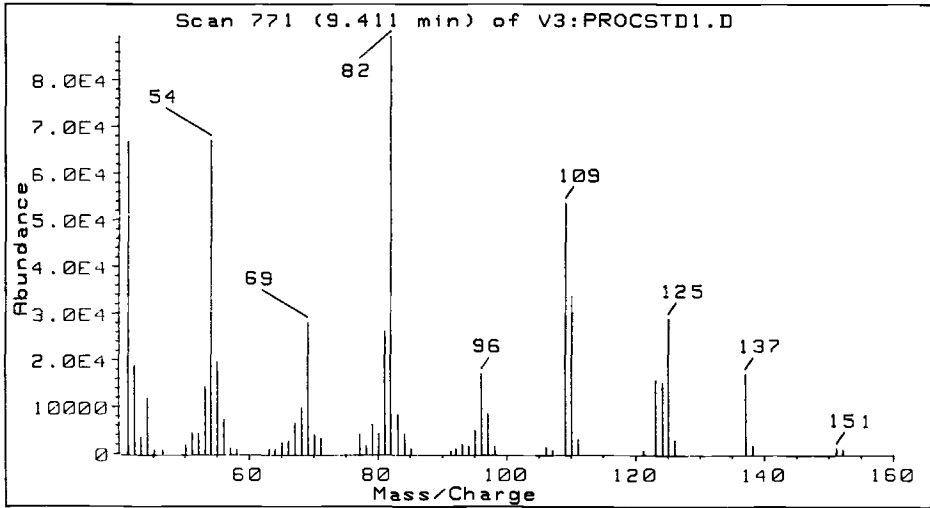


FIG. 14—The mass spectrum of N-ethylcyclohexanecarbonitrile.

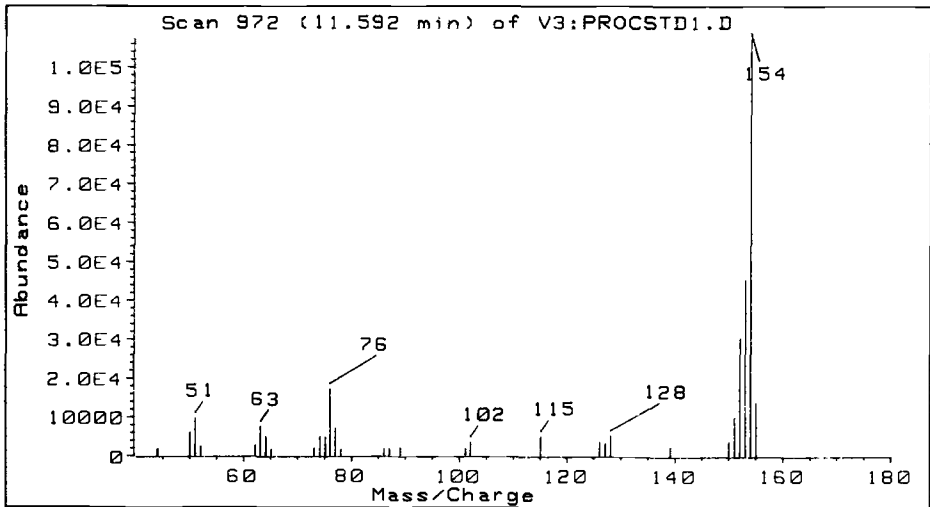


FIG. 15—The mass spectrum of biphenyl.

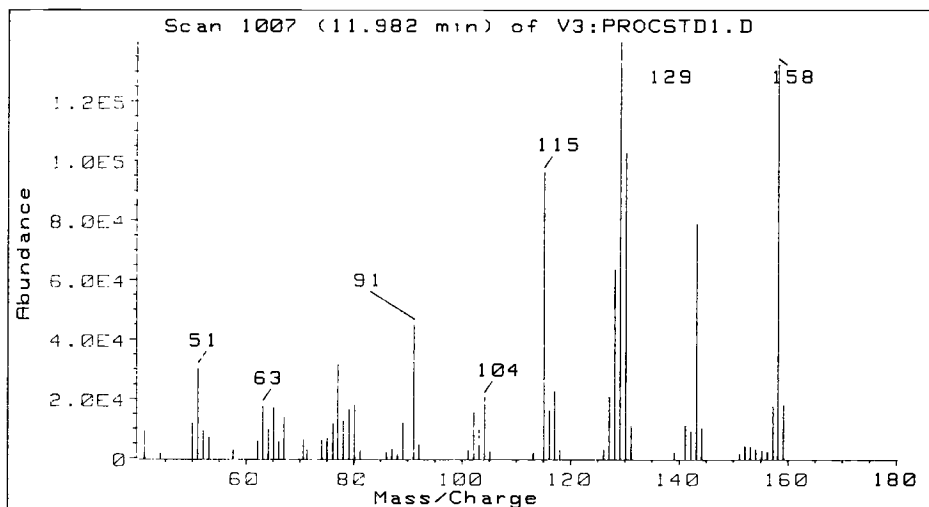


FIG. 16—The mass spectrum of 1-phenyl-1-cyclohexene.

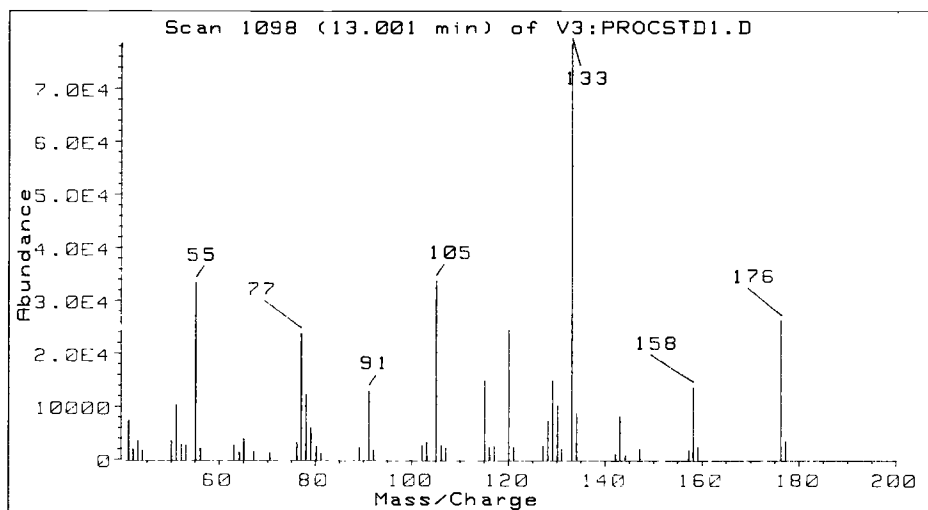


FIG. 17—The mass spectrum of 1-phenyl-1-cyclohexanol.

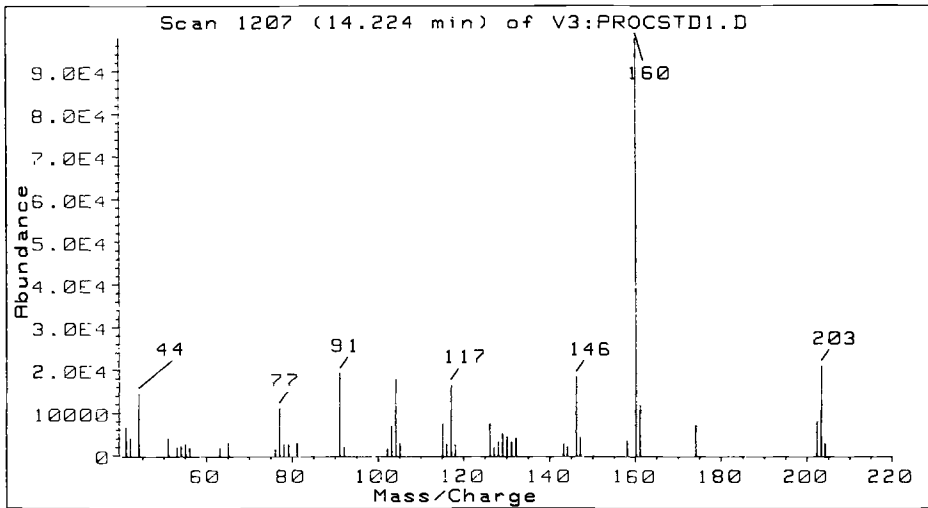


FIG. 18—The mass spectrum of *N*-ethyl-1-phenylcyclohexylamine.

### Reference Standard

A GC/MS mixed reference standard was prepared using the following compounds listed in Table 1.

Phenol and phenylethanol have also been found in *N*-ethyl-1-phenylcyclohexylamine solutions [8].

### Discussion

The only peak in the total ion chromatogram that would not be common to both methods of synthesis is due to *N*-ethylcyclohexanecarbonitrile. *N*-cyclohexylidenethylamine could be present in each of the chromatograms from the two reactions. *N*-ethylcyclohexanecarbonitrile can thermally break down via elimination of hydrogen cyanide (HCN) to yield *N*-cyclohexylidenethylamine. Because of the instability of the latter it is not very likely to be found except in solution (for example, petroleum ether) or in an inert atmosphere. On the other hand, the stable carbonitrile intermediate is more likely to be found in street samples and can therefore be used by the analyst to determine that synthetic route "B" was used to manufacture the *N*-ethyl-1-phenylcyclohexylamine.

TABLE 1—Compounds used for the GC/MS mixed reference standard.

Compound	Molecular Weight	Retention Time, min
1. Cyclohexanone	98	2.93
2. Bromobenzene	157	3.95
3. <i>N</i> -cyclohexylidenethylamine	125	6.19
4. <i>N</i> -ethylcyclohexanecarbonitrile	152	9.41
5. Biphenyl	154	11.59
6. 1-phenyl-1-cyclohexene	158	11.98
7. 1-phenyl-1-cyclohexanol	176	13.00
8. <i>N</i> -ethyl-1-phenylcyclohexylamine	203	14.22

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