

BROMINATIONS CONDUCTED WITH PYRIDINIUM BROMIDE PERBROMIDE

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Previously reported work has indicated that pyridinium bromide perbromide (pyridine hydrobromide perbromide) can be considered a general brominating agent which may be used in brominations ordinarily performed with molecular bromine, such as substitution on aromatic rings and additions to double bonds (1). It is not a specific brominating reagent such as N-bromosuccinimide (2) which is recommended for brominating the allyl position of an olefin. However, the use of peroxide type catalysts (3, 4) and aluminum or zinc chloride (5) have extended the scope of the brominations possible with N-bromosuccinimide. An excellent review of the reactions performed with brominating agents other than pyridinium bromide perbromide has been recently written by Carl Djerassi (6).

Pyridinium bromide perbromide (7, 8) $C_5H_6NBr \cdot Br_2$ is a red crystalline stable salt having the melting point 135–136° (dec.) with previous softening. The reagent has many advantages over dangerous liquid bromine. It is easily handled and stored and may be conveniently weighed. From its structural formula one would suspect that this perbromide can release free bromine, thus when substituted for bromine in any standard bromination the reaction should be expected to proceed in a normal manner. The experiments reported in this paper seem to verify the efficacy of pyridinium bromide perbromide as a substitute for bromine. The quantities of this reagent used were based on the presence of 45% available bromine, although the supplier has indicated 45–50% bromine available.

EXPERIMENTAL

Materials: The pyridinium bromide perbromide (PBPB) used in this study was supplied by Jasons Drug Company of Brooklyn, New York.

6-Bromo-2-naphthol (9). β -Naphthol (36 g., 0.25 mole) and 100 ml. of glacial acetic acid were placed in a 500-ml. round-bottom three-neck flask with a condenser, stirrer, and dropping-funnel. Pyridinium bromide perbromide (178 g.) was dissolved in 100 ml. of hot glacial acetic acid, and this solution was added to the β -naphthol through the dropping-funnel over a period of twenty minutes. The reaction was cooled slightly so as to effect a gentle reflux. The β -naphthol dissolved entirely as the addition took place. Then 25 ml. of water was added to the flask and the entire mixture heated to boiling. After Organic Syntheses (9), 39 g. of mossy tin was added and the mixture was refluxed for two hours. At the end of this period the mixture was cooled to 50° and filtered with suction.

To the filtrate was added 1.5 liters of water. A copious white precipitate formed which was washed three times with divided portions of 250 ml. of water. Upon air-drying the solid, 25 g. of a slightly pinkish powder, m.p. 122–124°, was obtained; yield 45.5%. For the classical

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method using bromine (9), a yield of 53–55 g. (96–100%) is claimed. The sample gave a mixed m.p. 122–123° with material (m.p. 123°) that had been prepared with liquid bromine.

Dibromostyrene (10). Small scale: Pyridinium bromide perbromide (3.4 g.) was dissolved in 3.0 ml. of absolute methyl alcohol and this solution was slowly added to 1.0 g. of styrene; upon cooling crystallization took place. After standing for 15 minutes the crystals were washed several times with absolute methanol. Yield, 1.0 g. (39.5%), m.p. 68.5–69.0°.

The preparation was repeated using glacial acetic acid as the solvent for pyridinium bromide perbromide. Yield, 1.5 g. (59.0%), m.p. 69.5–70.5°.

A similar experiment was carried out using ten times the quantities indicated for the small scale preparation in order to determine relative yields. Yield, 11.5 g. (45.3%), m.p. 71.5–72.0°.

Mixed melting points on all of the above samples with a sample of dibromostyrene (m.p. 71°) prepared with liquid bromine, were 70–71°.

For small scale preparations Cheronis, *et al.* (10) reported a 65% yield of dibromostyrene when bromine was employed.

TABLE I
COMPARATIVE BROMINATIONS

	PYRIDINIUM BROMIDE PERBROMIDE YIELD, %	ELEMENTAL BROMINE YIELD, %
6-Bromo-2-naphthol	45.5	96–100
Dibromostyrene	Small scale 39.5 Large scale 59.0 45.3	Small scale 65.0
2,4,6-Tribromophenol	Small scale 45.5 Large scale 71.0 56.8 ^a	Small scale 51.2–56.9
2,4,6-Tribromoaniline	Small scale 29.7 Large scale 24.8	Small scale 49.5–50.4

^a No potassium bromide present.

2,4,6-Tribromophenol (11). Small scale run, Solution No. 1: Potassium bromide (0.8 g.) was dissolved in 5.0 ml. of boiling water and 1.1 g. of pyridinium bromide perbromide was dissolved in 2.0 ml. of absolute methyl alcohol; the two solutions were mixed. It was found that the potassium bromide solution had to be maintained at an elevated temperature during the addition of the perbromide solution as otherwise the pyridinium bromide perbromide would drop out of solution. Solution No. 2: Phenol (0.1 g.) was dissolved in 1.0 ml. of absolute methyl alcohol and 1.0 ml. of water.

The perbromide-bromide mixture was slowly added to the phenolic solution; during the addition a yellow color was produced. The reaction mixture was permitted to stand for 15 minutes, and 4.0 ml. of water was added. The heavy precipitate which resulted was washed three times with water. The product was dissolved in 2.0 ml. of hot absolute methanol and filtered; cold water was added dropwise until crystallization was complete. Upon air-drying the recrystallized product 0.16 g. (45.5%), m.p. 89°, was isolated. A 51.2–56.9% yield was reported by Cheronis, *et al.* (10).

The preparation was repeated using ten times the quantities indicated for the small scale run; yield, 2.5 g. (71.0%), m.p. 88–88.5°.

Mixed melting points of both products were 89–90° when taken with tribromophenol (m.p. 88–90°) prepared from elemental bromine.

Another preparation was made using the larger quantities, but without potassium bromide. Yield, 2.0 g. (56.8%), m.p. 93–93.5°; mixed m.p. 90–91°.

2,4,6-Tribromoaniline (12). Small scale run: Pyridinium bromide perbromide (1.8 g.) was dissolved in 2.0 ml. of hot glacial acetic acid. To this hot solution was added 0.31 g. of aniline. Intense white fumes resulted. The reaction mixture was permitted to stand for 15 minutes with occasional agitation, and 20 ml. of water was added. Precipitation occurred at this point. The precipitate was washed with cold water, and recrystallized from hot absolute methyl alcohol by the addition of cold water to the hot filtrate. Yield 0.3 g. (29.7%), m.p. 119°. A yield of 49.5–59.4% was reported by Cheronis, *et al.* (11) in a similar experiment.

A large scale preparation was attempted using ten times the quantities indicated in the small scale; yield 2.5 g. (24.8%) m.p. 119–120°.

Mixed melting points of both products were 116–117° using a sample of tribromoaniline (m.p. 118°) prepared from liquid bromine.

The comparative yields obtained with pyridinium bromide perbromide and as reported with elemental bromine are recorded in Table I.

SUMMARY

Pyridinium bromide perbromide, a brominating agent, was substituted for elemental liquid bromine in the bromination of β -naphthol, styrene, aniline, and phenol.

Although no variables were studied the results of the experiments were satisfactory and verified the efficacy of this perbromide as a safe and convenient reagent for performing brominations.

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