

Study on A New Synthetic Method of 4-Bromophthalic Anhydride and The Synthesis of Pure 4-Phenylethynylphthalic Anhydride (4-PEPA)

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ABSTRACT:

In this paper, a new method of synthesis of 4-bromophthalic anhydride is reported, that was, N-methyl 4-nitrophthalimide (4-NPI) was firstly reduced to 4-aminophthalimide (4-API), and then be hydrolyzed to di-sodium 4-amino-phthalate, and the pure 4-bromophthalic anhydride (4-BPA) had been prepared by the Sandmeyer reaction. This process should be an ideal method for synthesis of 4-BPA in laboratory.

KEYWORDS:

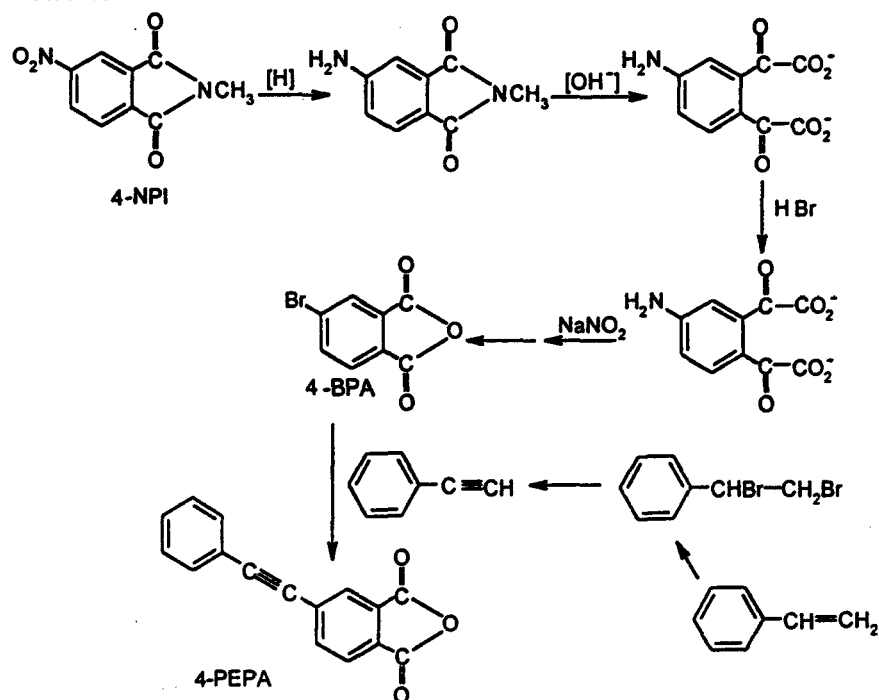
4-nitrophthalimide (4-NPI), 4-bromophthalic anhydride (4-BPA), 4-Phenylethynylphthalic Anhydride(4-PEPA), Sandmeyer reaction

4-Bromo phthalic anhydride (4-BPA) is a useful intermediate for organic synthesis. For example, a remarkable high performance material, PETI-5^[1] and other polyimide end-capped with phenylethynyl materials being researched and developed by NASA of U.S.A in recent years were prepared by using 4-phenylethynyl phthalic anhydride (4-PEPA) as a end-capping reagent. At present, this end-capping reagent, 4-PEPA is generally synthesized by the reaction of 4-BPA with phenyl acetylene. 4-BPA can be synthesized by the oxidation of 4-bromo-o-xylene or 6-bromonaphthol under their aerial phase. By the bromination of o-xylene to prepare 4-bromo-o-xylene, it always formed a considerable amount, generally about 3~4% of byproduct, 3-bromo-o-xylene besides the main product. This byproduct could not easily be removed by distillation. Thus, there will undoubtedly be a considerable amount of 3-bromo-phthalic anhydride in the product of oxidation of bromo-o-xylene. This byproduct would induce the existence of a number of 3-PEPA in the final product, 4-PEPA, and hence the properties of the polyimide materials end-capped with 4-PEPA would be seriously sacrificed. Pure 4-bromophthalic anhydride can also be obtained by air oxidation of 6-bromo-naphthol, but as it was well known that the process of air oxidation is inconvenient and only is the scale enough large, this process could be economically desirable.

There have been many reports of successful example about the oxidation of mono alkyl substituent on aromatic ring with aqueous solution of potassium permanganate or concentrated nitric acid, but in our experiments, we found that the first alkyl group on the aromatic ring was easily oxidated by concentrated nitric acid; the second alkyl group on the aromatic ring, however, could hardly not be oxidated by concentrated nitric acid at usual condition. We tried the oxidation of 4-bromo-o-xylene with aqueous solution of potassium permanganate and concentrated nitric acid respectively, we found that this method not only expended large amount of oxidant, but also took a so long period of reaction that it looked as if we could not find the end of the reaction ever using concentrated nitric acid as oxidant. Another shortcoming was both of the processes would give rise environmental pollution seriously for producing large amount of waste gas, waste water and industrial residue. The result for oxidation of 4-bromo-o-xylene in solution may be better under high pressure of oxygen than under ambient pressure. A successful example preparing 4-bromobenzoic anhydride in liquid-phase oxidation under ambient pressure had been performed by Michinori ŌKI et al^[2]. They reported that they

refluxed the mixture of 4-bromo-2-ethyl-acetyl benzene with diluted nitric acid first for five hours and then further refluxed thus obtained intermediate with diluted aqueous solution of KMnO_4 to get 4-bromo-phthalic anhydride. This result should be definitely attributed to the presence of the carbonyl group in the aromatic ring. Obviously, the carbonyl group induced easy oxidability of the alkyl group of 4-bromo-2-ethyl-acetyl benzene. It was reported^[3] that bromophthalic anhydride can be easily obtained through directly bromination of phthalic anhydride. In our experiments, however, the product of the bromination of phthalic anhydride was a mixture of 3-bromo-phthalic anhydride, 4-bromo-phthalic anhydride and di-bromophthalic anhydride. Though the amount of the byproduct, di-bromo-phthalic anhydride, could be reduced by adjusting the reaction conditions and it can be removed from the reaction products, it was difficult to separate the 3-bromofrom the 4-bromo phthalic anhydride, or to reduce the yield of either of the two isomers.

In our production of N-methyl 4-nitrophthalimide (4-NPI), although a little amount of N-methyl 3-nitrophthalimide (3-NPI) could also be produced during the nitration of N-methyl phthalimide with concentrated nitric acid, we still got pure 4-NPI, because the byproduct, 3-NPI, was easy cleared away. We supposed that we could get pure product using 4-NPI as starting material via Sandmeyer reaction in the synthesis of 4-BPA conveniently. The synthetic schema is showed as follow:



4-NPI was first reduced to N-methyl 4-amino-phthalimide, and the latter is then hydrolyzed to disodium 4-amino-phthalate. 4-amino-o-phthalic acid has been obtained by acidifying the disodium 4-amino-phthalate with hydrobromic acid. Finally, we get pure 4-bromo-phthalic anhydride via Sandmeyer reaction of 4-amino-o-phthalic acid. The 4-BPA synthesized with above synthetic route was colorless and had the melting point of $104\text{--}107^\circ\text{C}$ ($105\text{--}106^\circ\text{C}$ in the literature^[2]). Yield: $> 40\%$ based on 4-NPI. The elemental analysis, calcd. for $\text{C}_8\text{H}_5\text{BrO}_3$, was: Br, 35.42%; found: Br, 35.20%. ^1H NMR, ^{13}C NMR and IR were in accord with the molecule structure of 4-BPA. ^1H NMR, ^{13}C NMR of 4-BPA are showing in Fig. 1 and Fig. 2 respectively. We believed that this synthetic route would provide a relatively convenient method for the synthesis of the pure 4-BPA in a small scale. The 4-PEPA synthesized from the reaction of the 4-BPA prepared in our laboratory with phenylacetylene was yellow in color and has a melting point of $148\text{--}151^\circ\text{C}$ in contrast to 151°C (DSC) reported by Hergenrother et. Al^[1]. ^1H NMR spectrum and ^{13}C NMR spectrum of the 4-PEPA synthesized in our laboratory were

in accord with the molecule structure of the designed compound. ^1H NMR and ^{13}C NMR of the 4-PEPA were showed in Fig. 3 and Fig. 4.

References:

- 1, Hergenrother et. al, U.S.P. 5,567,800(1996)
- 2, Michinori ÔKI et al, Estrogenic Biphenyls, 30(5), 508(1957)
- 3, C.A. Spencer et al , U.S.P. 2,394,268(1944)

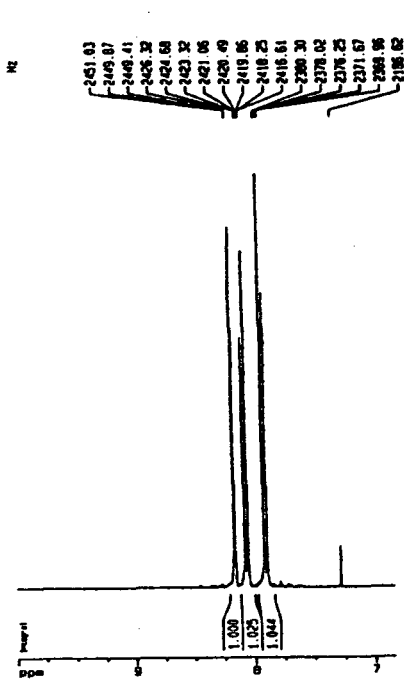


Fig. 1, ^1H NMR of 4-BPA

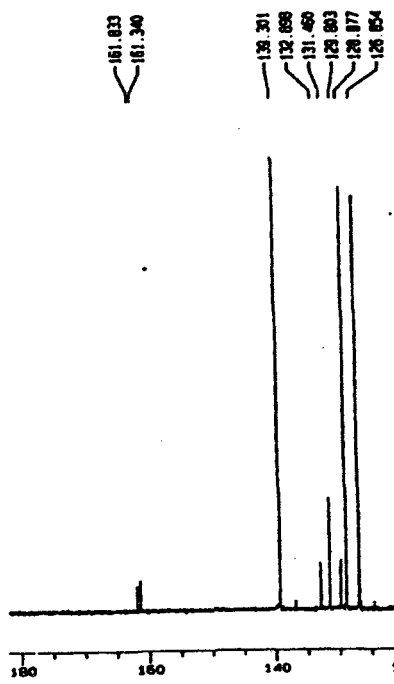


Fig. 1, ^{13}C NMR of 4-BPA

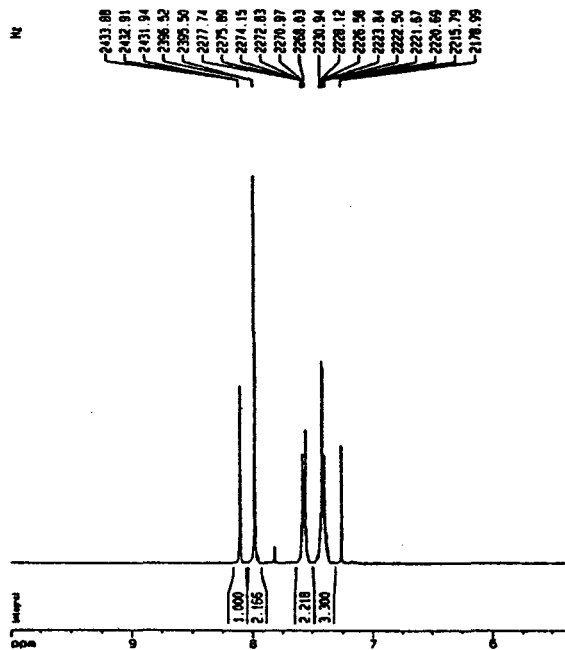


Fig. 3, ^1H NMR of 4-PEPA

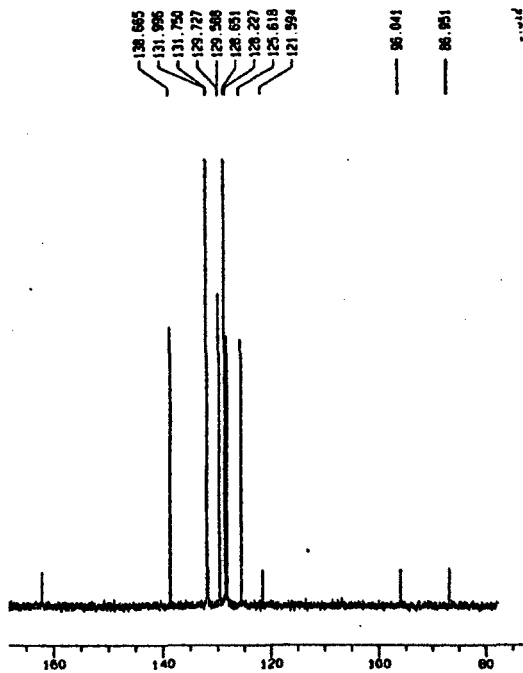


Fig. 4, ^{13}C NMR of 4-PEPA