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(54) Titre : PROCEDE DE SEPARATION ET DE PURIFICATION D'ACIDES HYDROXYNAPHTALENECARBOXYLIQUES
(54) Title: METHOD OF SEPARATION AND PURIFICATION OF HYDROXYNAPHTHALENECARBOXYLIC ACIDS

(57) Abrégé/Abstract:
The present invention provides a method for effectively separating independent hydroxynaphthalene-carboxylic acids by treating a mixture containing various kinds of hydroxynaphthalene-carboxylic acids with nonionic porous synthetic adsorbents having as a basic structure aromatic copolymers mainly composed of styrene and divinyl benzene or methacrylic copolymers mainly composed of monomethacrylates and dimethacrylates.

ABSTRACT

The present invention provides a method for effectively separating independent hydroxynaphthalene-carboxylic acids by treating a mixture containing various kinds of hydroxynaphthalene-carboxylic acids with nonionic porous synthetic adsorbents having as a basic structure aromatic copolymers mainly composed of styrene and divinyl benzene or methacrylic copolymers mainly composed of monomethacrylates and dimethacrylates.

METHOD OF SEPARATION AND PURIFICATION OF HYDROXYNAPHTHALENECARBOXYLIC ACIDS

TECHNICAL FIELD AND BACKGROUND

The present invention relates to a method of separation and purification of hydroxynaphthalenecarboxylic acids.

Hydroxynaphthalenecarboxylic acids such as 2-hydroxynaphthalene-6-carboxylic acid are important raw materials of aromatic polyesters, and indispensable especially to the production of liquid crystalline polymers excellent in workability and fluidity, and resins or fibers having high elasticity and high heat resistance. Further, 2-hydroxynaphthalene-3-carboxylic acid and 2-hydroxynaphthalene-3,6-dicarboxylic acid are useful as raw materials for azo type pigments or dyes.

2-Hydroxynaphthalene-6-carboxylic acid (referred to as "BON6" hereinafter) and 2-hydroxynaphthalene-3-carboxylic acid (referred to as "BON3" hereinafter) have been produced from the reaction of alkaline salts of β-naphthol and carbon dioxide by Kolbe-Schmitt reaction (Japanese Patent Application KOKAI Sho. 57-95939, Japanese Patent Application KOKAI Sho. 57-197244, Japanese Patent Application KOKAI Sho. 58-99436, and Japanese Patent Application KOKAI Sho. 63-146843 etc.). The reaction mixtures obtained according to the above reaction contain isomers such as BON3, BON6 and other impurities in addition to the desired products.

Recently, it has been found that 2-hydroxynaphthalene-3,6-dicarboxylic acid (referred to as "BON3,6" hereinafter) can be obtained in high yield by the reaction of potassium salt of 2-naphthol and carbon dioxide under a specific condition, but substantial amounts of BON6 and BON3 are still contained in the reaction mixture.

As these hydroxynaphthalenecarboxylic acids vary in use and properties, the purification of the products is indispensable, and various purification processes have been proposed.

For example, as a method for the separation and purification of BON6, a process has been proposed in which water is added to the reaction mixture and the pH value is adjusted to approximately 3 - 4 with a mineral acid such as hydrochloric acid, sulfuric acid and the like to deposit a crude BON6, and then the crude product is washed with water-alcohol solvent such as diluted methanol to separate BON6 and BON3.

Other methods such that crude BON6 is subjected to crystallization in an aqueous solution containing aliphatic ethers (Japanese Patent Application KOKAI Hei

1-216955), and the BON6 is separated by crystallization as the dioxane adduct so as to obtain the BON6 from the adduct (Japanese Patent Application KOKAI Hei 2-15046 and KOKAI Hei 2-218643).

Similar methods have been used for the separation of BON3,6 from BON3 and BON6, but these methods were not sufficient and it was impossible to obtain separated and purified products in high purity from the reaction mixtures containing impurities in large amounts.

DISCLOSURE OF THE INVENTION

The present invention relates to a method of separation and purification of hydroxynaphthalenecarboxylic acids, which comprises treating a solution containing a mixture of two or more kinds of hydroxynaphthalenecarboxylic acids with a nonionic porous synthetic adsorbent having as a basic structure aromatic copolymers mainly composed of styrene and divinylbenzene or methacrylic copolymers mainly composed of monomethacrylates and dimethacrylates. After treatment in this manner, separating into each hydroxynaphthalenecarboxylic acid.

In the present specification, "treatment with adsorbents" means a process including a previous dissolution of hydroxynaphthalenecarboxylic acids in a solvent, an adsorption of the solution obtained, and a selective extraction with a solvent or an elution through a column packed with an adsorbent.

In the present specification, "hydroxy-naphthalenecarboxylic acids" include not only hydroxynaphthalene monocarboxylic acids but also polycarboxylic acids such as dicarboxylic acids, tricarboxylic acids, tetracarboxylic acids and the like.

The nonionic porous synthetic adsorbents having as the basic structure aromatic copolymers mainly composed of styrene and divinylbenzene or methacrylic copolymers mainly composed of monomethacrylates and dimethacrylates suitable for use in the present invention are known. The nonionic porous synthetic adsorbents having as a basic structure aromatic copolymers mainly composed of styrene and divinylbenzene include DIAION (trade mark; available from Mitsubishi Kagaku K.K.) HP10, HP20, HP21, HP30, HP40, HP50, SP850 and SP205, AMBERLITE (trade mark; available from Rohm & Haas Co.) XAD2 and XAD4, and the like, and the nonionic porous synthetic adsorbents having as a basic structure methacrylic copolymers mainly composed of monomethacrylates and dimethacrylates as main monomers include DIAION HP2MG, AMBERLITE XAD7 and XAD8, and the like.

The nonionic porous synthetic adsorbents suitable for use in the present invention are porous crosslinked polymers, having a specific surface area and a pore volume in significant quantities. The adsorbents have suitably a specific surface area of not less than 100 m^2/g, preferably not less than 400 m^2/g, and a pore volume of not less than 0.1 ml/g, preferably 1.0 ml/g or more. In the case of the adsorbents having a specific surface area of less than 100 m^2/g or a pore volume of less than 0.1 ml/g the adsorbing amount is influenced and the separating ability tends to worsen.

As aforementioned, BON6 is prepared according to Kolbe-Schmitt reaction, in which BON3 is produced as a by-product. The amount of BON3 as by-product depends on the process of production of BON6, but the BON3 itself is a useful compound as a raw material of pigments or dyes. Accordingly one purpose of the present invention is to separate BON6 and BON3, which can also achieve the purification of BON6 containing other impurities or by-products.

According to the present invention, BON3 is more strongly adsorbed by the above adsorbents than BON6, and other impurities are also adsorbed. Therefore, when the solution containing BON6 with the impurities and the by-products such as BON3 is treated with the above adsorbents, these impurities and by-products are adsorbed so as to eliminate them from the solution containing BON6.

A mixture of hydroxynaphthalenecarboxylic acids containing BON3 as main products can also be prepared according to Kolbe-Schmitt reaction. In this case, since BON6 is produced as a by-product, BON6 is first eluted, and BON3 is second eluted with the same or another solvent. Depending on the reaction conditions BON3,6 is also produced as a by-product. In this case, BON6 is first eluted, and then it may be recovered with the same or other solvent as set forth hereinafter.

Further, BON3,6 is useful as a raw material for azo type pigments or dyes, and as aforementioned, a reaction mixture for production of BON3,6 contains BON3 and BON6. It has been found that BON3,6 has an almost intermediate adsorptivity to the nonionic porous synthetic adsorbent between that of BON3 and BON6. Accordingly it can also be separated or purified in a similar manner. For example, when the mixture of BON3, BON6 and BON3,6 is eluted through a column with the nonionic porous synthetic adsorbent, BON6, BON3,6 and BON3 are recovered in this order. In case of the mixture of BON6 and BON3,6, the BON6 is eluted first, and in case of the mixture of BON3 and BON3,6, the BON3,6 is eluted first.

According to the present invention, the separation and recovery of hydroxynaphthalenecarboxylic acids adsorbed may be achieved by a solvent which can dissolve desired hydroxynaphthalenecarboxylic acids.

As such solvents there are exemplified polar solvents, for example, alcohols such as methanol, n-propanol and the like; ketones such as acetone, methyl ethyl ketone and the like; ethers such as diethyl ether, tetrahydrofuran and the like; amides such as dimethylformamide and the like; sulfur compounds such as dimethylsulfoxide and the like; aliphatic hydrocarbons such as hexane, heptane and the like; aromatic hydrocarbons such as benzene, toluene and the like; organic acids such as acetic acid and the like; organic acids esters such as ethyl acetate and the like; and water. These solvents may be selected according to the kind of adsorbents. Preferred solvents are alcohols, especially methanol. Two or more kinds of solvents can be used as mixed if desired.

BON3, BON3,6 and BON6 may be separated and purified depending on the difference of adsorptivity to an adsorbent using a single solvent which can dissolve them, or recovered by selective extraction using a solvent which can specifically dissolve the objective compound, or successively eluted using solvents having a different solubility to each compound.

The treatment by the nonionic porous synthetic adsorbents may be carried out by a batch process or a continuous process, and any method of an adsorbing separation process by a batchwise operation or an elution using a column.

When the column is used for the treatment of the present invention, an adsorption column chromatography is convenient. As a developing solvent for the column chromatography, any solvent which can dissolve BON6, BON3, and BON3,6 may be used. As such solvents, there are concretely exemplified alcohols such as methanol, n-propanol and the like; ketones such as acetone, methyl ethyl ketone and the like; ethers such as diethyl ether, tetrahydrofuran and the like; amides such as dimethylformamide and the like; sulfur compounds such as dimethylsulfoxide and the like; aliphatic hydrocarbons such as hexane, heptane and the like; aromatic hydrocarbons such as benzene, toluene and the like; organic acids such as acetic acid and the like; organic acid esters such as ethyl acetate and the like; and water. These solvents can be selected according to the kinds of adsorbents. Preferred solvents are alcohols, especially methanol. Two or more kinds of solvents can be used as mixed if desired. The separation ability can be improved by controlling the ratio of the mixture. The development may be carried out by successive alteration of the solvents.

The present invention may be also used to increase the ratio of desired hydroxynaphthalenecarboxylic acids by repeating the treatment of the invention. Alternatively the concentration and ratio of the desired hydroxynaphthalenecarboxylic acids may be increased using an artificial moving bed and the like as described in Japanese Patent Application KOKAI Hei 2-49159.

According to the present invention, the hydroxynaphthalenecarboxylic acids can be purified to a sufficient level for industrial practical use, but when a higher purity is still required, known purification methods such as recrystallization may be used.

The present invention is illustrated using BON6, BON3, and BON3,6, but it is not restricted to these hydroxynaphthalenecarboxylic acids.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a graph illustrating the recovering ratios of each of BON6 and BON3 to the outflow cumulative volumetric ratio, and the change of ratio of BON6 in Example 1.

Fig. 2 is a graph illustrating the recovering ratios of each of BON6 and BON3 to the outflow cumulative volumetric ratio, and the change of ratio of BON6 in Example 2.

Fig. 3 is a graph illustrating the recovering ratios of each of BON6 and BON3 to the outflow cumulative volumetric ratio, and the change of ratio of BON6 in Example 3.

Fig. 4 is a graph illustrating the recovering ratios of each of BON6 and BON3 to the outflow cumulative volumetric ratio, and the change of ratio of BON6 in Example 4.

Fig. 5 is a graph illustrating the recovering ratios of each of BON6 and BON3 to the outflow cumulative volumetric ratio, and the change of ratio of BON6 in Comparative Example 1.

Fig. 6 is a graph illustrating the recovering ratios of each of BON6 and BON3 to the outflow cumulative volumetric ratio, and the change of ratio of BON6 in Comparative Example 2.

Fig. 7 is a graph illustrating the recovering ratios of each of BON6 and BON3 to the outflow cumulative volumetric ratio, and the change of ratio of BON6 in Comparative Example 3.

Fig. 8 is a graph illustrating the change of recovering ratios of each of BON6 and BON3 to the outflow cumulative volumetric ratio in Example 5.

Fig. 9 is a graph illustrating the change of ratio of BON6 to the outflow cumulative volumetric ratio and that of BON3 respectively in Example 5.

Fig. 10 is a graph illustrating the change of recovering ratios of each of BON6 and BON3 to the outflow cumulative volumetric ratio in Example 6.

Fig. 11 is a graph illustrating the change of ratio of BON6 to the outflow cumulative volumetric ratio and that of BON3 respectively in Example 6.

Fig. 12 is a graph illustrating the change of recovering ratios of each of BON6, BON3 and BON3,6 to the outflow cumulative volumetric ratio in Example 7.

Fig. 13 is a graph illustrating the change of ratio of BON6 to the outflow cumulative volumetric ratio and those of BON3 and BON3,6 respectively in Example 7.

EXAMPLE

Example 1

As a column for separation and purification, a glass column (inner diameter of 28 mm and length of 400 mm) is packed with 200 ml of a nonionic porous synthetic adsorbent containing as a basic structure aromatic copolymers mainly composed of styrene and divinylbenzene (DIAION HP20, available from Mitsubishi Kagaku K.K., specific surface area: 605 m^2/g, pore volume (mercury porosimetry): 1.18 ml/g) as suspended in methanol. On the other hand, BON6 (available from Ueno Seiyaku K.K.) 2.9 g and BON3 (available from Ueno Seiyaku K.K.) 11.0 g were dissolved in methanol to prepare a solution 100 g.

The solution 5.0 g was weighed to put into the upper portion of the synthetic adsorbent layer in the column packed, and then developed as eluting methanol at a rate of 6.2 ml/minute at room temperature. The methanol solution eluted from the outlet of the column was fractionated about every 15 ml up to about 400 ml in total.

Each fraction was weighed, and then the concentrations of each of BON6 and BON3 therein were determined by a high speed liquid chromatography (600 E type pump, 441 type UV detector, made by Waters Corp.).

According to the analysis result, the amount of the eluted methanol is converted to the volumetric ratio of the packed adsorbent (referred to as outflow cumulative volumetric ratio hereinafter) and recorded on the abscissa. According to the following equations, the recoveries of each of BON6 and BON3, and the ratio of BON6 in each fraction was calculated, which is shown in Fig. 1.

$$\text{Recovery of BON6 (\%)} = \frac{\text{weight of BON6 in fraction}}{\text{weight of BON6 in 5 g of solution}} \times 100$$

$$\text{Recovery of BON3 (\%)} = \frac{\text{weight of BON3 in fraction}}{\text{weight of BON3 in 5 g of solution}} \times 100$$

$$\text{Ratio of BON6 (\%)} = \frac{\text{weight of BON6 in fraction}}{\text{weight of BON6 and BON3 in fraction}} \times 100$$

As is apparent from Fig. 1, BON6 was eluted in the fractions of the outflow cumulative volumetric ratio of 0.6 - 1.4, and BON3 eluted in the each fraction of 0.8 to

2.4, and both could be separated. Further, BON6 could be recovered in a ratio of not less than 93% and a recovery of 71.4 % in the outflow cumulative volumetric ratio of 0.5 - 1.0. The ratio of BON3 was not less than 98% and the recovery was 78.5 %.

Example 2

The methanol was developed according to the same manner as Example 1 except that DIAION SP850 (specific surface area: 995 m^2/g, pore volume (nitrogen porosimetry): 1.20 ml/g, available from Mitsubishi Kagaku K.K.) was used; the amount of BON6 in the solution was 2.8 g and the amount of BON3 was 11.4 g, and the methanol solution eluted from the outlet of the column was fractionated about every 30 ml.

According to the same manner as Example 1, each fraction was weighed, the concentrations of BON6 and BON3 in each fractionated solution were determined, and the recovery of each of BON6 and BON3 in each fraction, and the ratio of BON6 were calculated. The results are shown in Fig. 2.

As is apparent from Fig. 2, BON6 was eluted in the fractions of the outflow cumulative volumetric ratio of 0.8 - 2.0, and BON3 was eluted in the fractions of 1.3 - 3.8, so that both could be separated. Further, BON6 could be recovered at the ratio of not less than 99 % and the recovery of 79.2 % in the outflow cumulative volumetric ratio of 0.9 - 1.1. The ratio and the recovery of BON3 were not less than 96 % and 96.4 % respectively.

Example 3

The methanol development was carried out according to the same manner as Example 2 except that DIAION SP205 (specific surface area: 507 m^2/g, pore volume (mercury porosimetry): 1.04 ml/g, available from Mitsubishi Kagaku K.K.) was used as an adsorbent.

According to the same manner as in Example 2, each fraction was weighed, the concentrations of BON6 and BON3 in each fractionated solution were determined, and the recovery of each of BON6 and BON3 in each fraction and the ratio of BON6 were calculated. The results are shown in Fig. 3.

As is apparent from Fig. 3, BON6 was eluted in the fractions of the outflow cumulative volumetric ratio of 0.6 - 1.8, and BON3 was eluted in the fractions of 0.9 - 3.4, so that both could be separated. Further, BON6 could be recovered at a ratio of not less than 92 % and a recovery of 63.0 % in the outflow cumulative volumetric ratio of 0.7 - 0.9. The ratio and the recovery of BON3 were not less than 92 % and 81.5 % respectively.

Example 4

The methanol development was carried out according to the same manner as Example 2 except that

DIAION HP2MG (nonionic porous synthetic adsorbent having as a main structure methacrylic type copolymers mainly composed of monomethacrylates and dimethacrylates; specific surface area: 473 m^2/g, pore volume (mercury porosimetry): 1.15 ml/g, available from Mitsubishi Kagaku K.K.) was used as an adsorbent.

According to the same manner as Example 2, each fraction was weighed, the concentrations of BON6 and BON3 in each fractionated solution were determined, and the recovery of each of BON6 and BON3 in each fraction and the ratio of BON6 were calculated. The results are shown in Fig. 4.

As is apparent from Fig. 4, BON6 was eluted in the fractions of the outflow cumulative volumetric ratio of 0.6 - 2.0, and BON3 was eluted in the fractions of 0.9 - 2.9, so that both can be separated. Further, BON6 could be recovered at a ratio of not less than 52 % and a recovery of 32.8 % in the outflow cumulative volumetric ratio of 0.7 - 0.9. The ratio and the recovery of BON3 were not less than 91 % and 33.2 % respectively.

Comparative Example 1

The methanol development was carried out according to the same manner as Example 2 except that a cationic ion exchange resin (DIAION PK216H, available from Mitsubishi Kagaku K.K.) was used as an adsorbent.

According to the same manner as Example 2 each fraction was weighed, the concentrations of BON6 and BON3 in each fractionated solution were determined, and the recovery of each of BON6 and BON3 in each fraction and the ratio of BON6 were calculated. The results are shown in Fig. 5.

Each fraction (0.3 - 2.8) in which BON6 was eluted contains BON3 in an amount of not less than 76% together with BON 6, so that BON6 could not be separated.

Comparative Example 2

The methanol development was carried out according to the same manner as Example 2 except that a cationic ion exchange resin (DIAION SK204H, available from Mitsubishi Kagaku K.K.) was used as an adsorbent.

According to the same manner as Example 2, each fraction was weighed, the concentrations of BON6 and BON3 in each fractionated solution were determined, and the recoveries of each of BON6 and BON3 in each fraction and the ratio of BON6 were calculated. The results are shown in Fig. 6.

Each fraction (0.4 - 2.6) in which BON6 was eluted contains BON3 in an amount of not less than 66% together with BON 6, which means that BON6 could not be separated.

Comparative Example 3

The methanol development was carried out according to the same manner as Example 2 except that polyamides (Polyamide C-100™, available from Wako Junyaku K.K.) was used as an adsorbent.

According to the same manner as Example 2, each fraction was weighed, the concentrations of BON6 and BON3 in each fractionated solution were determined, and the recovery of each of BON6 and BON3 in each fraction and the ratio of BON6 were calculated. The results are shown in Fig. 7.

Each fraction (0.4 - 1.4) in which BON6 was eluted contains BON3 in an amount of not less than 65% together with BON 6, so that BON6 could not be separated.

Comparative Examples 4, 5 and 6

The methanol developments were carried out according to the same manner as Example 2 except that an anionic ion exchange resin (DIAION WA10: available from Mitsubishi Kagaku K.K.), an anionic ion exchange resin (DIAION WA20: available from Mitsubishi Kagaku K.K.), and activated carbon for chromatography (available from Wako Junyaku K.K.) were used as adsorbents respectively.

According to the same manner as Example 2, each fraction was weighed, the concentrations of BON6 and BON3 in each fractionated solution were determined, but BON6 and BON3 were not detected in any fractions, which were retained in the adsorbents respectively.

Comparative Example 7

The methanol development was carried out according to the same manner as Example 2 except that a silica gel (Wakogel™ C-200: available from Wako Junyaku K.K.) was used as an adsorbent.

According to the same manner as Example 2, each fraction was weighed, the concentrations of BON6 and BON3 in each fractionated solution were determined, but BON6 and BON3 were detected in every fraction as they were before this treatment, which flowed out without adsorption.

Example 5

The methanol development was carried out according to the same manner as Example 1 except that the methanol solution 100 g was prepared by dissolving BON6 (18.3 g) and BON3 (2.0 g) in methanol.

According to the same manner as Example 1, each fraction was weighed, the concentrations of BON6 and BON3 in each fraction were determined, and the recoveries of each of BON6 and BON3 in each fraction (Fig. 8) and the ratios thereof (Fig. 9) were calculated respectively.

BON 6 were recovered in a ratio of not less than 99% and the recovery of 91.7%, and BON3 was recovered in a ratio of not less than 99% and the recovery of 60.0%.

Example 6

The methanol development was carried out according to the same manner as Example 2 except that the methanol solution 100 g was prepared by dissolving BON6 (18.3 g) and BON3 (2.0 g) in methanol.

According to the same manner as Example 2, each fraction was weighed, the concentrations of BON6 and BON3 in each fraction were determined, and the recoveries of each of BON6 and BON3 in each fraction (Fig. 10) and the ratios thereof (Fig. 11) were calculated respectively.

BON 6 was recovered in a ratio of not less than 99% and the recovery of 96.4%, and BON3 was recovered in a ratio of not less than 99% and the recovery of 71.0%.

Example 7

The methanol development was carried out according to the same manner as Example 2 except that the methanol solution 100 g was prepared by dissolving BON6 (0.25 g), BON3 (0.24 g) and BON3,6 (0.72 g) in methanol.

According to the same manner as Example 2, each fraction was weighed, the concentrations of BON6, BON3 and BON3,6 in each fraction were determined, and the recoveries of each of BON6, BON3 and BON3,6 in each fraction (Fig. 12) and the ratios thereof (Fig. 13) were calculated respectively.

BON 6 was recovered in a ratio of not less than 66% and the recovery of 62.1%, BON3 was recovered in a ratio of not less than 91% and the recovery of 44.0%, BON3,6 was recovered in a ratio of not less than 93% and the recovery of 64.8%.

Comparative Example 8

The methanol development was carried out according to the same manner as Example 7 except that activated carbon for chromatography (available from Wako Junyaku K.K.) was used as an adsorbent.

According to the same manner as Example 7, each fraction was weighed, the concentrations of BON6, BON3 and BON3,6 in each fractionated solution were determined, but BON6, BON3 and BON3,6 were not detected in any fraction, which were retained as adsorbed.

Comparative Example 9

The methanol development was carried out according to the same manner as Example 7 except that a silica gel (Wakogel C-200: available from Wako Junyaku K.K.) was used as an adsorbent.

According to the same manner as Example 7, each fraction was weighed, the concentrations of BON6, BON3 and BON3,6 in each fractionated solution were determined, but BON6, BON3 and BON3,6 were detected as they were in every fraction, which were not adsorbed and flowed out.

As can be seen from the above results, hydroxynaphthalenecarboxylic acids such as BON3, BON6, BON3,6 and the like can be separated and purified using a nonionic porous synthetic adsorbent having as a basic structure aromatic copolymers mainly composed of styrene and divinylbenzene or methacrylic copolymers mainly composed of monomethacrylates and dimethacrylates.

CLAIMS:

1. A method of separation and purification of hydroxynaphthalenecarboxylic acids which comprises treating a solution containing a mixture of two or more kinds of hydroxynaphthalenecarboxylic acids with a nonionic porous synthetic adsorbent having as a basic structure aromatic copolymers mainly composed of styrene and divinylbenzene as main monomers or methacrylic copolymers mainly composed of monomethacrylates and dimethacrylates.

2. A method of separation and purification of claim 1, in which the mixture of hydroxynaphthalene-carboxylic acids contains at least two kinds of compounds selected from 2-hydroxynaphthalene-3-carboxylic acid, 2-hydroxynaphthalene-6-carboxylic acid and 2-hydroxynaphthalene-3,6-dicarboxylic acid.

3. A method of separation and purification of claim 1, in which the treatment with an adsorbent is carried out by adsorption column chromatography.

Fig.1

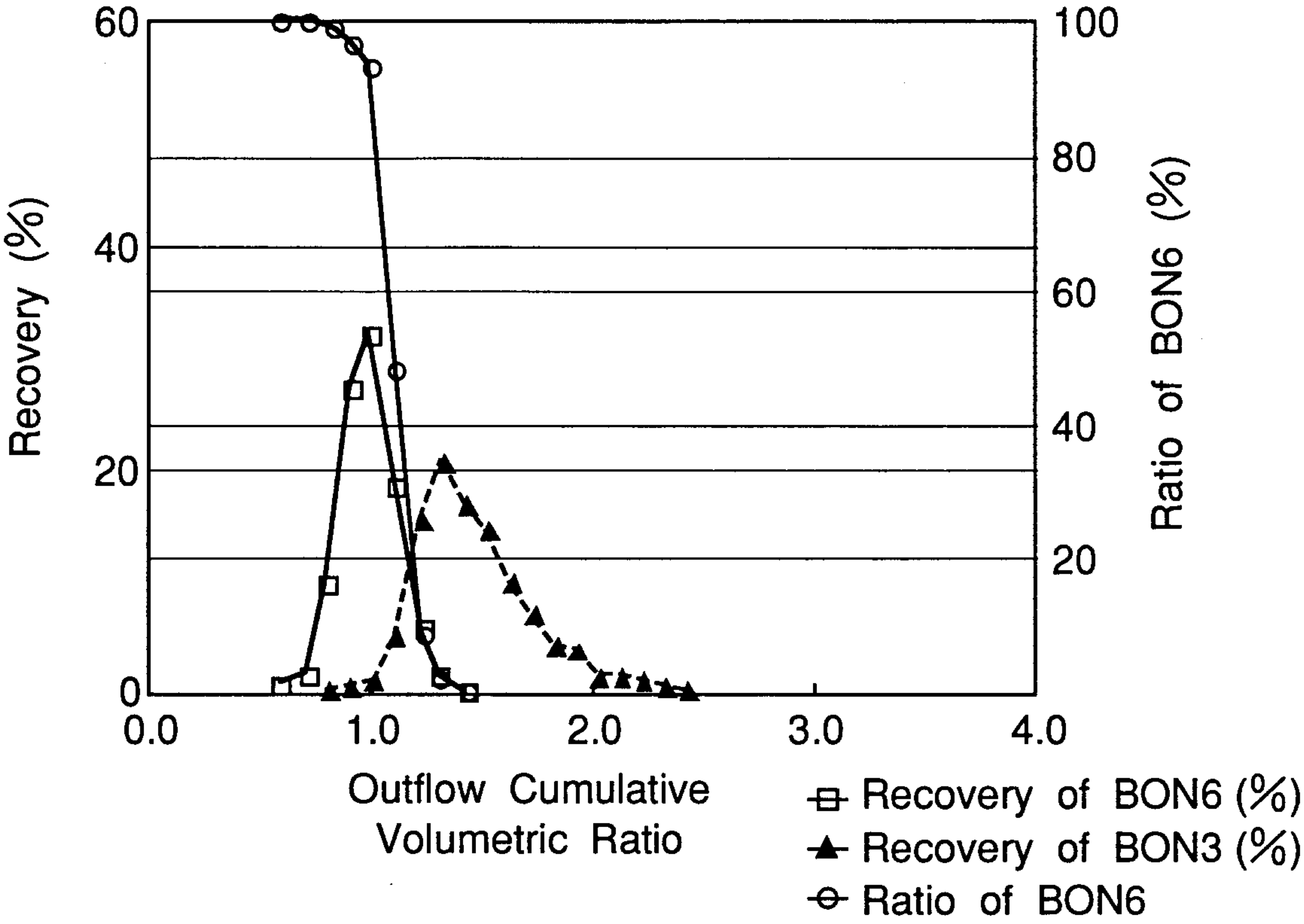

60
40
20
0
100
80
60
40
20
Recovery (%)
Ratio of BON6 (%)
0.0
1.0
2.0
3.0
4.0
Outflow Cumulative Volumetric Ratio
Recovery of BON6 (%)
Recovery of BON3 (%)
Ratio of BON6

Fig.2

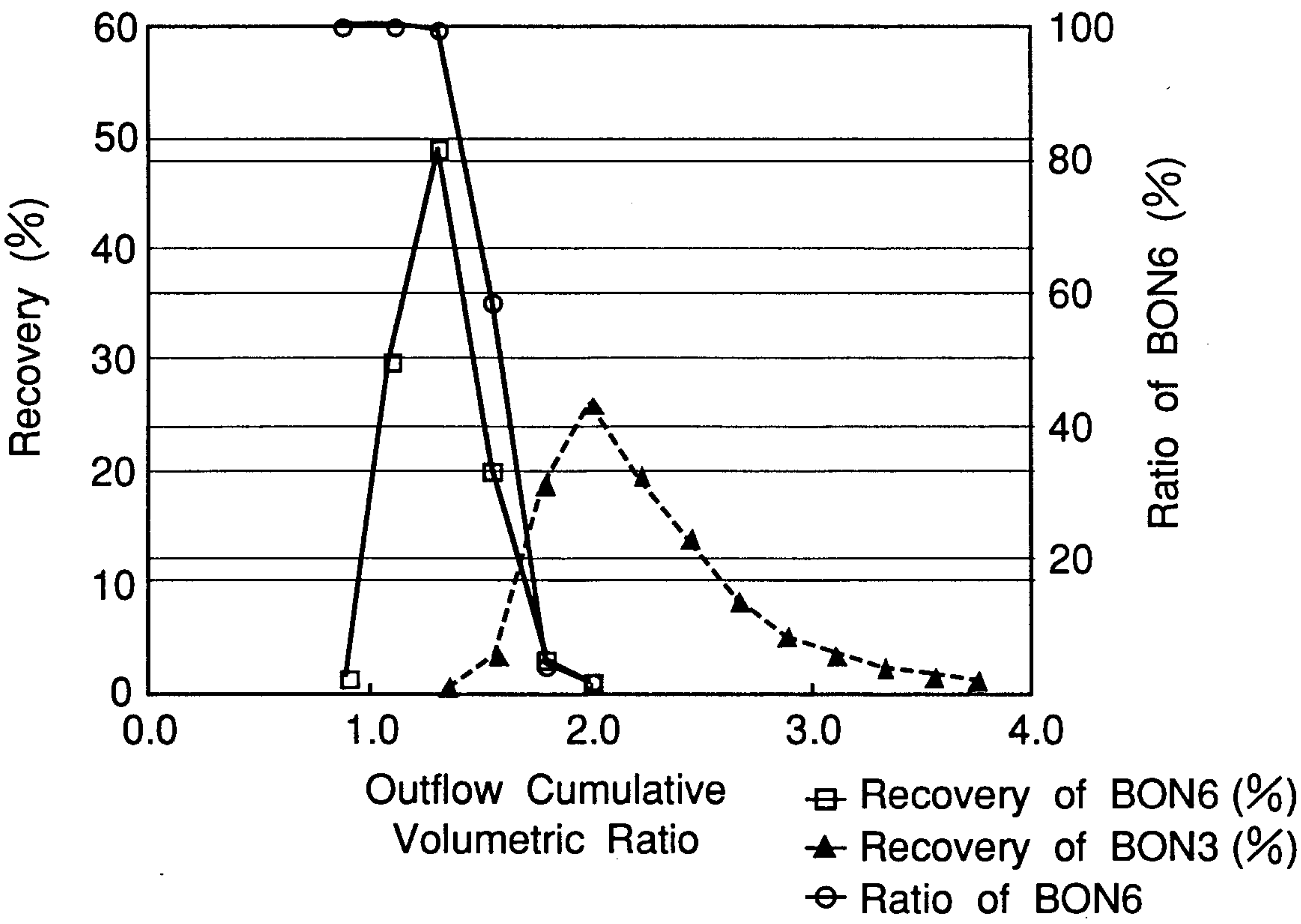

60
50
40
30
20
10
0
100
80
60
40
20
Recovery (%)
Ratio of BON6 (%)
0.0
1.0
2.0
3.0
4.0
Outflow Cumulative Volumetric Ratio
Recovery of BON6 (%)
Recovery of BON3 (%)
Ratio of BON6

Fig.3

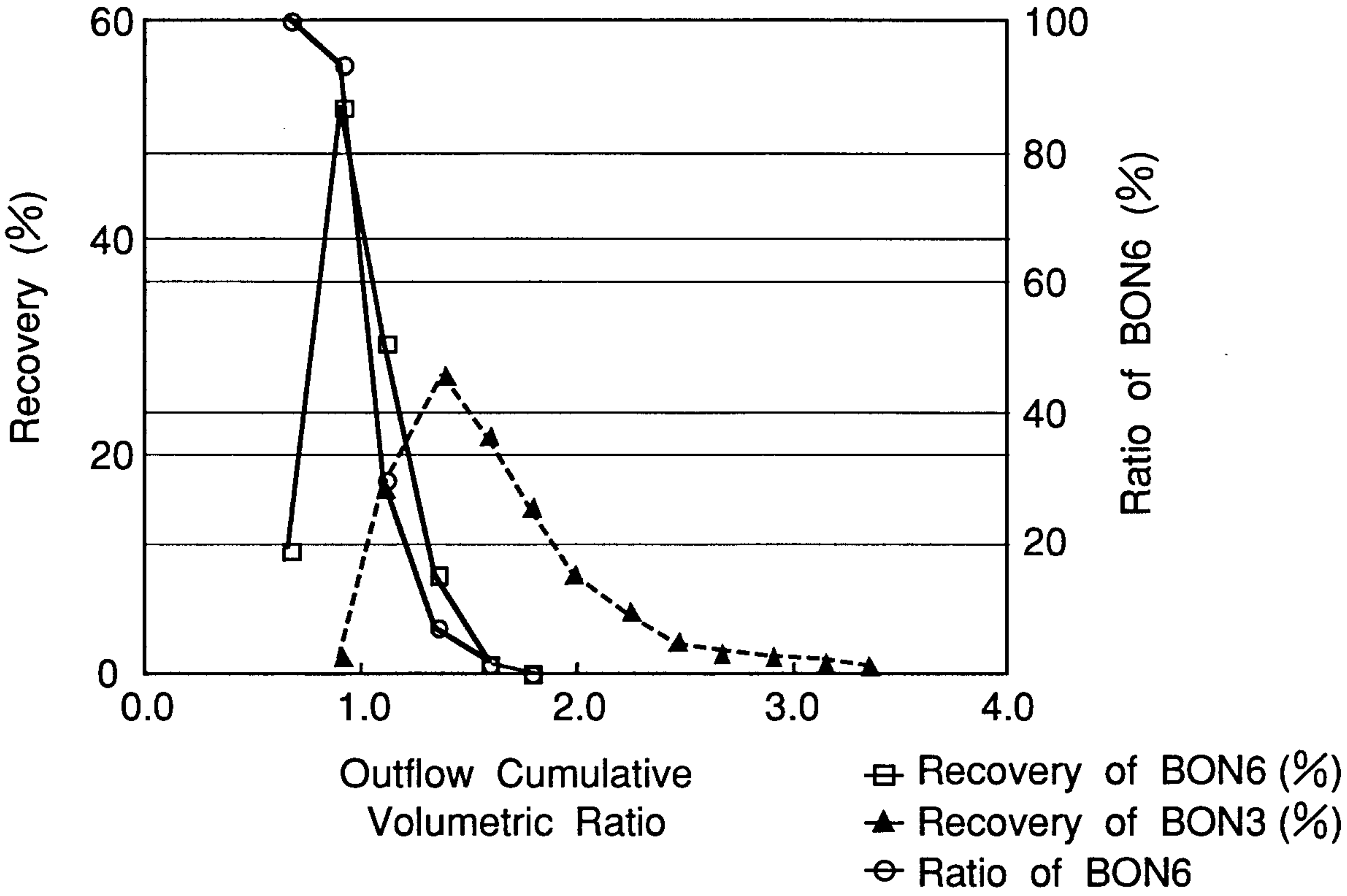

60
40
20
0
Recovery (%)
100
80
60
40
20
Ratio of BON6 (%)
0.0
1.0
2.0
3.0
4.0
Outflow Cumulative Volumetric Ratio
Recovery of BON6 (%)
Recovery of BON3 (%)
Ratio of BON6

Fig.4

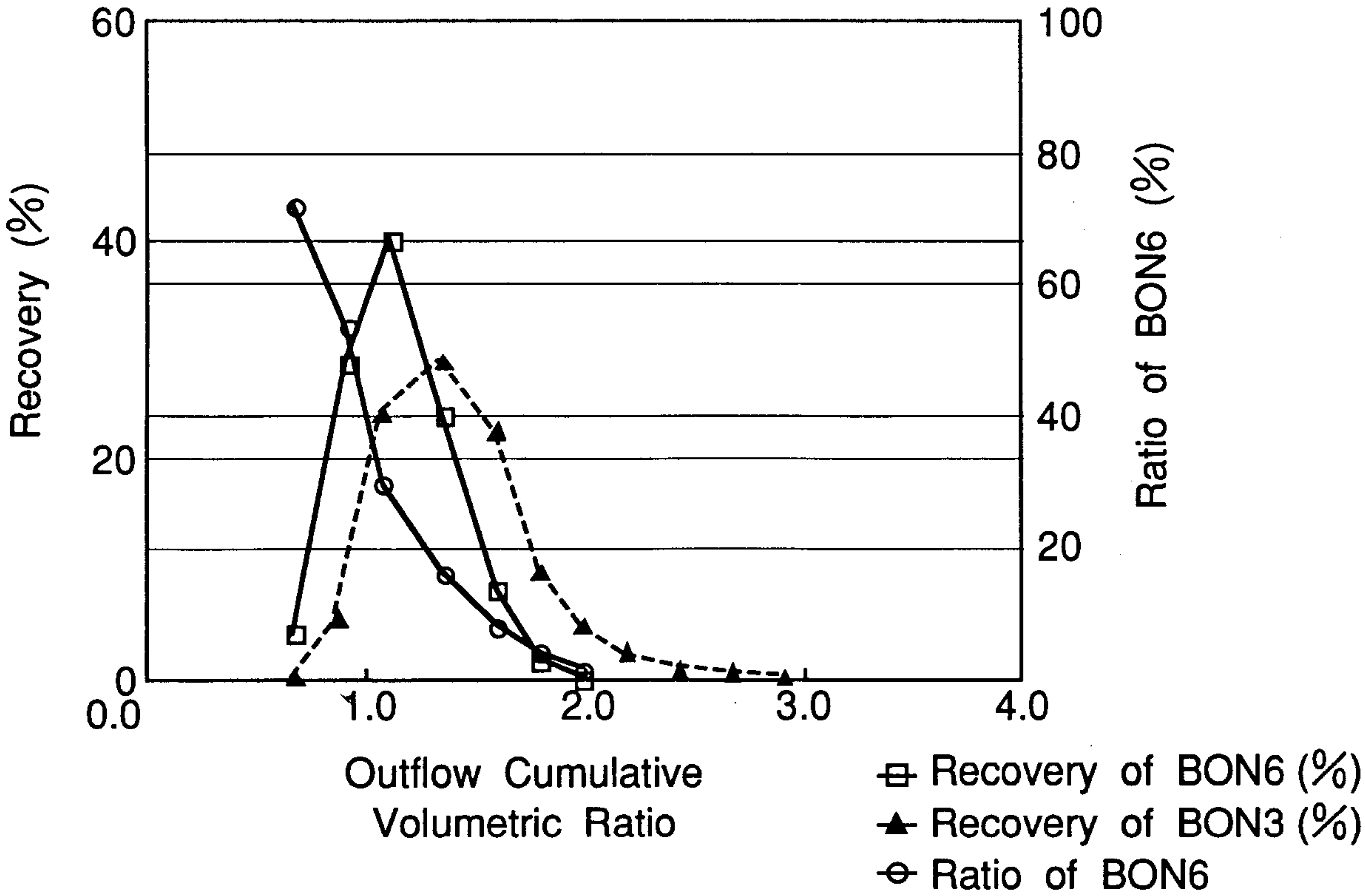

60
40
20
0
Recovery (%)
100
80
60
40
20
Ratio of BON6 (%)
0.0
1.0
2.0
3.0
4.0
Outflow Cumulative Volumetric Ratio
Recovery of BON6 (%)
Recovery of BON3 (%)
Ratio of BON6

Fig.5

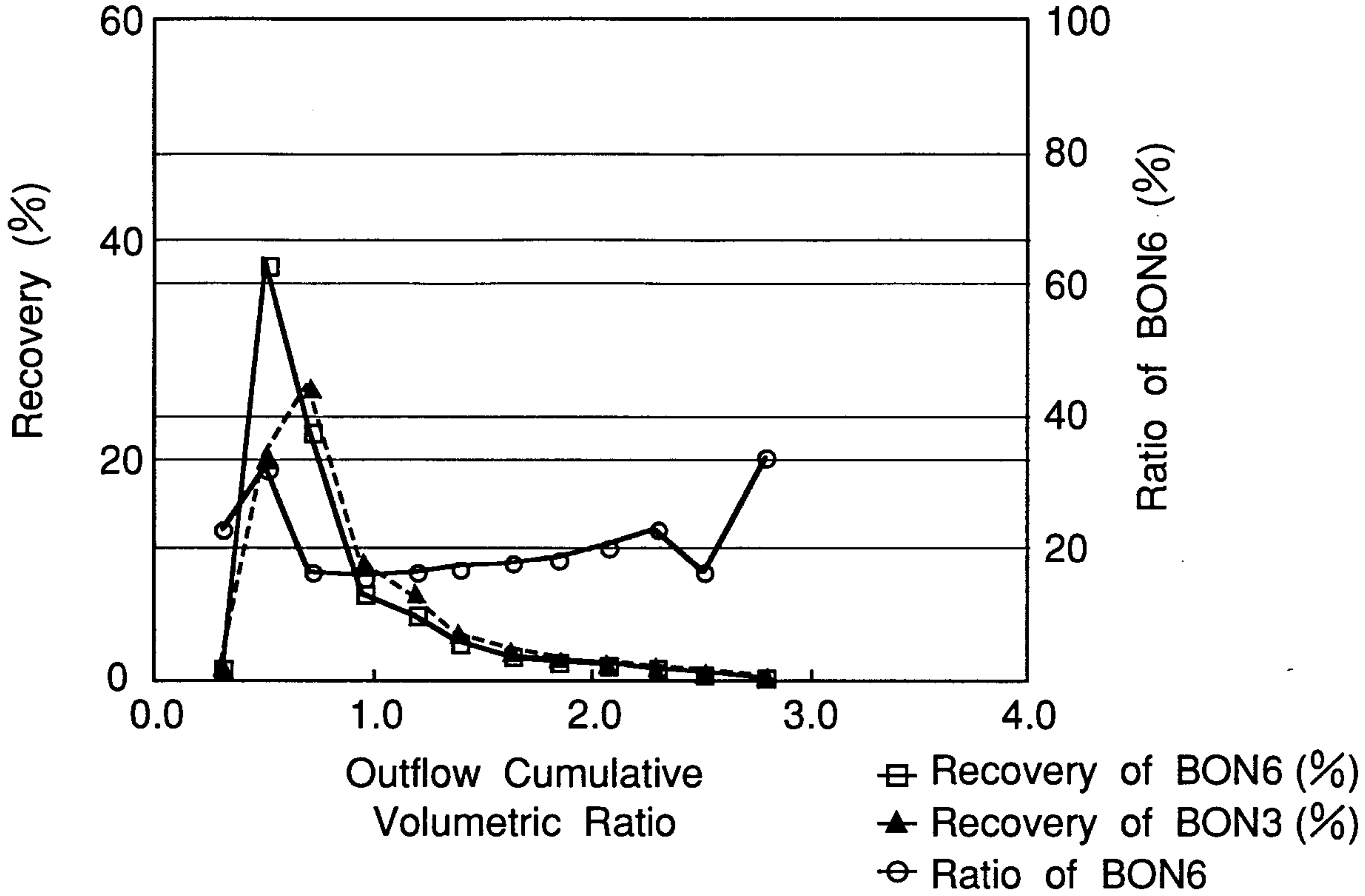

60
40
20
0
100
80
60
40
20
Recovery (%)
Ratio of BON6 (%)
0.0
1.0
2.0
3.0
4.0
Outflow Cumulative
Volumetric Ratio
Recovery of BON6 (%)
Recovery of BON3 (%)
Ratio of BON6

Fig.6

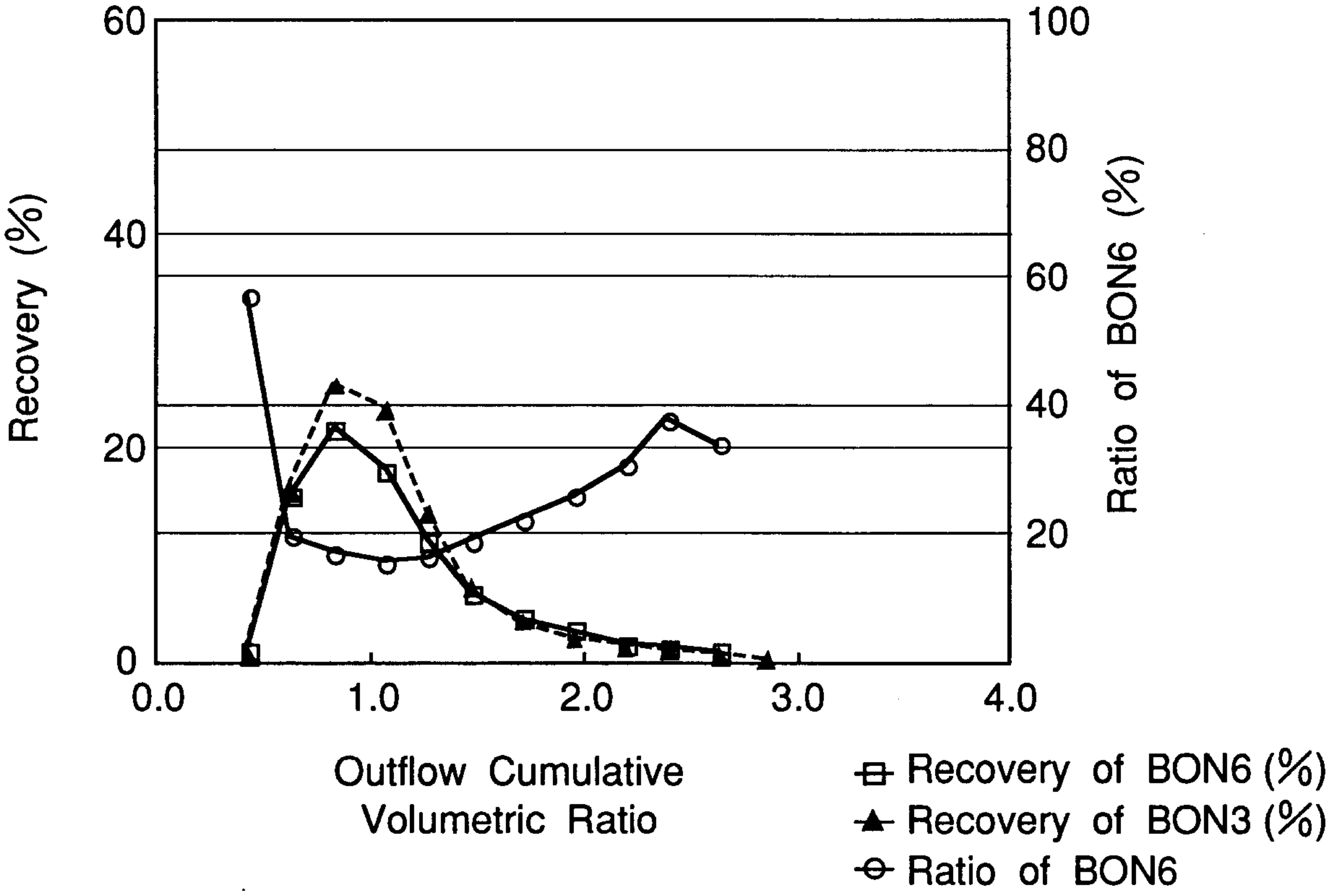

60
40
20
0
100
80
60
40
20
Recovery (%)
Ratio of BON6 (%)
0.0
1.0
2.0
3.0
4.0
Outflow Cumulative
Volumetric Ratio
Recovery of BON6 (%)
Recovery of BON3 (%)
Ratio of BON6

Fig.7

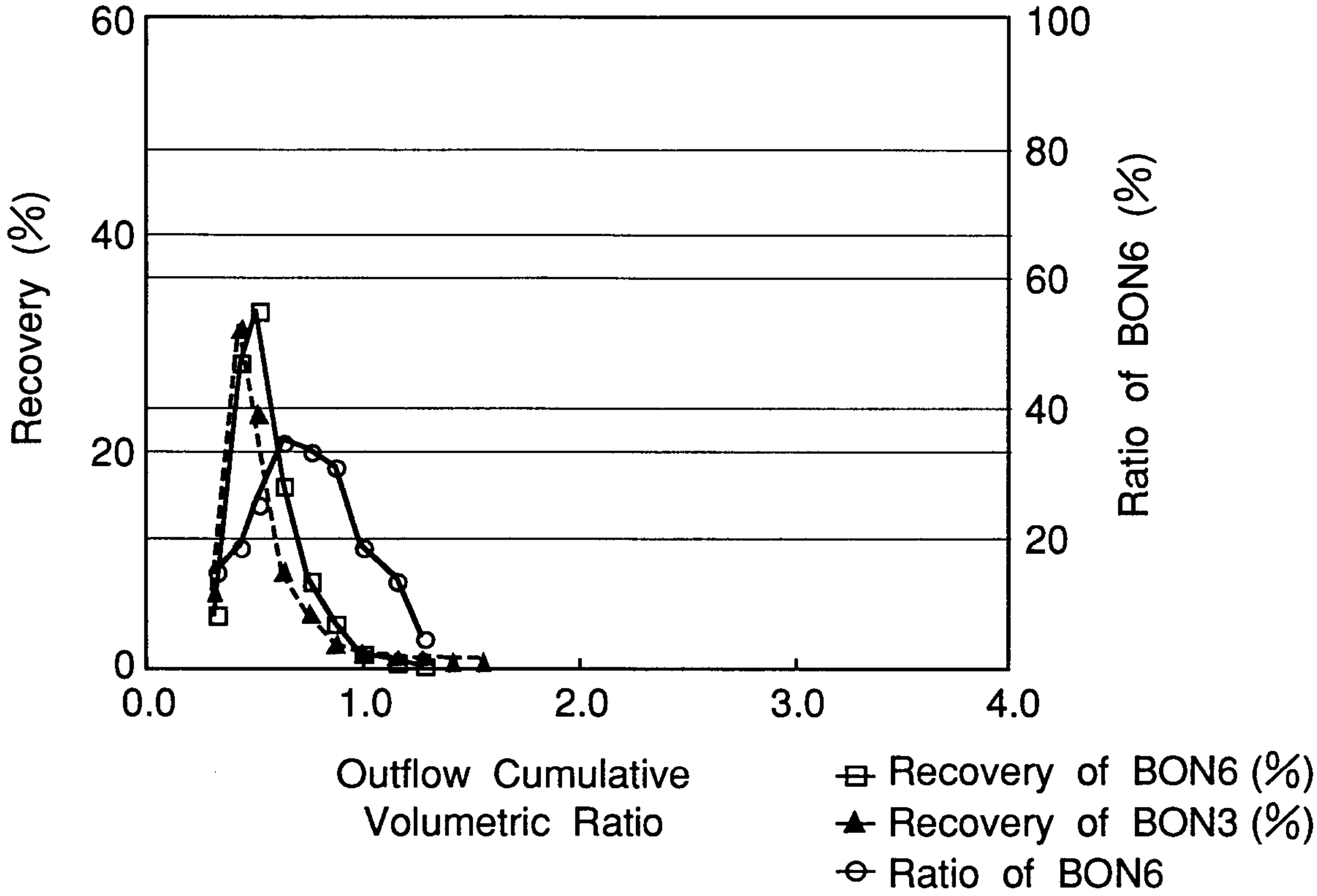

60
40
20
0
Recovery (%)
100
80
60
40
20
Ratio of BON6 (%)
0.0
1.0
2.0
3.0
4.0
Outflow Cumulative Volumetric Ratio
Recovery of BON6 (%)
Recovery of BON3 (%)
Ratio of BON6

Fig.8

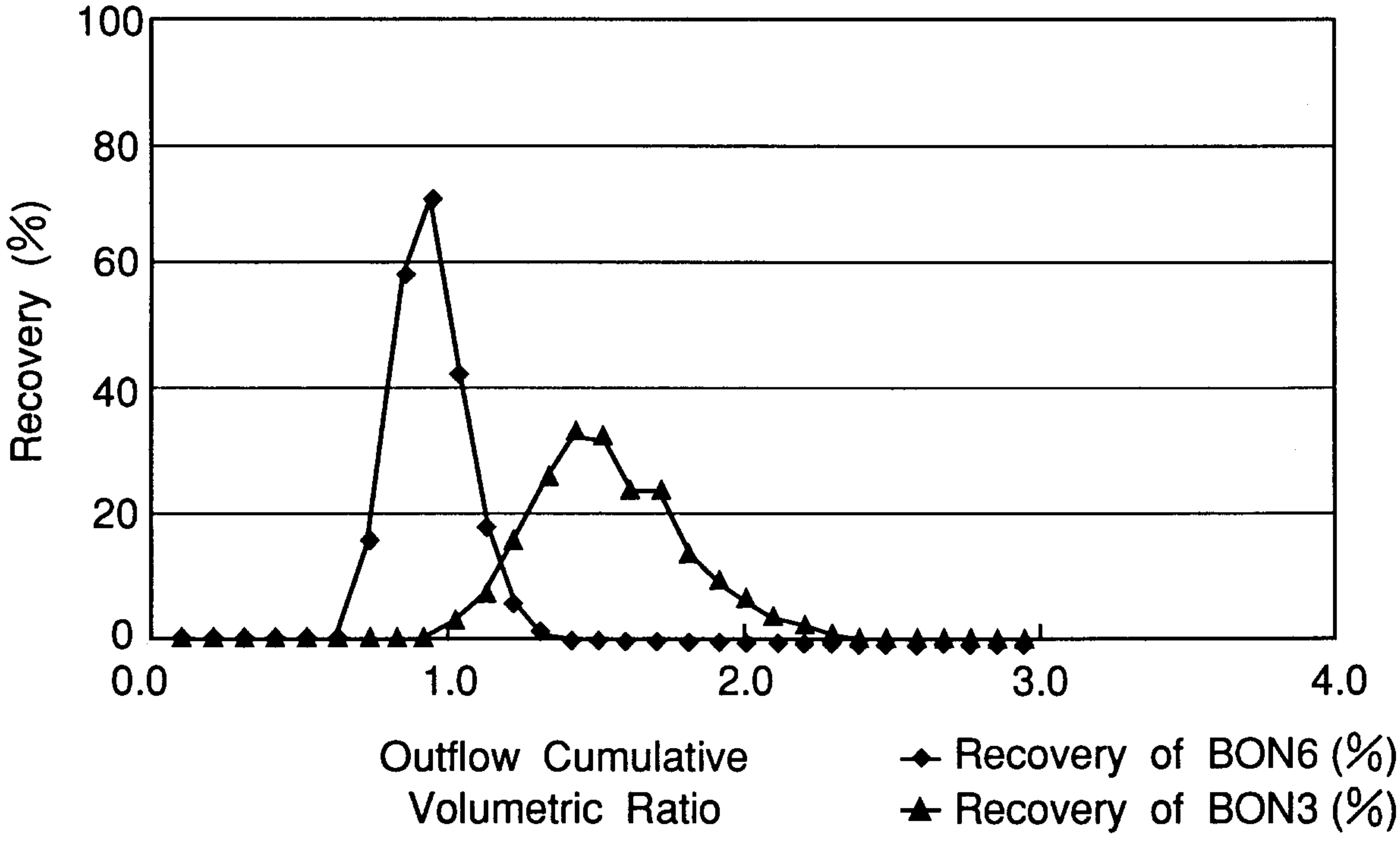

100
80
60
40
20
0
Recovery (%)
0.0
1.0
2.0
3.0
4.0
Outflow Cumulative Volumetric Ratio
Recovery of BON6 (%)
Recovery of BON3 (%)

Fig.9

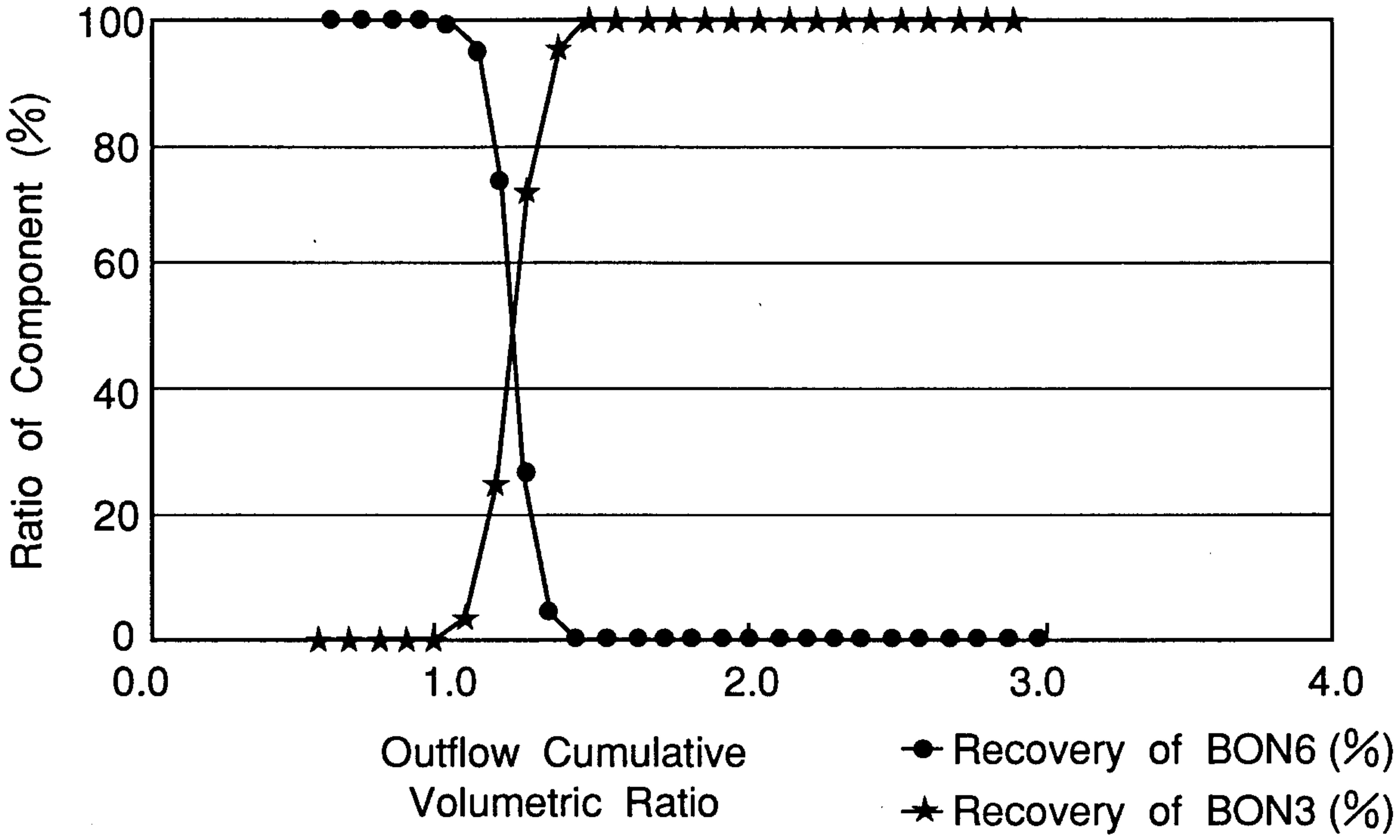

100
80
60
40
20
0
Ratio of Component (%)
0.0
1.0
2.0
3.0
4.0
Outflow Cumulative
Volumetric Ratio
Recovery of BON6 (%)
Recovery of BON3 (%)

Fig.10

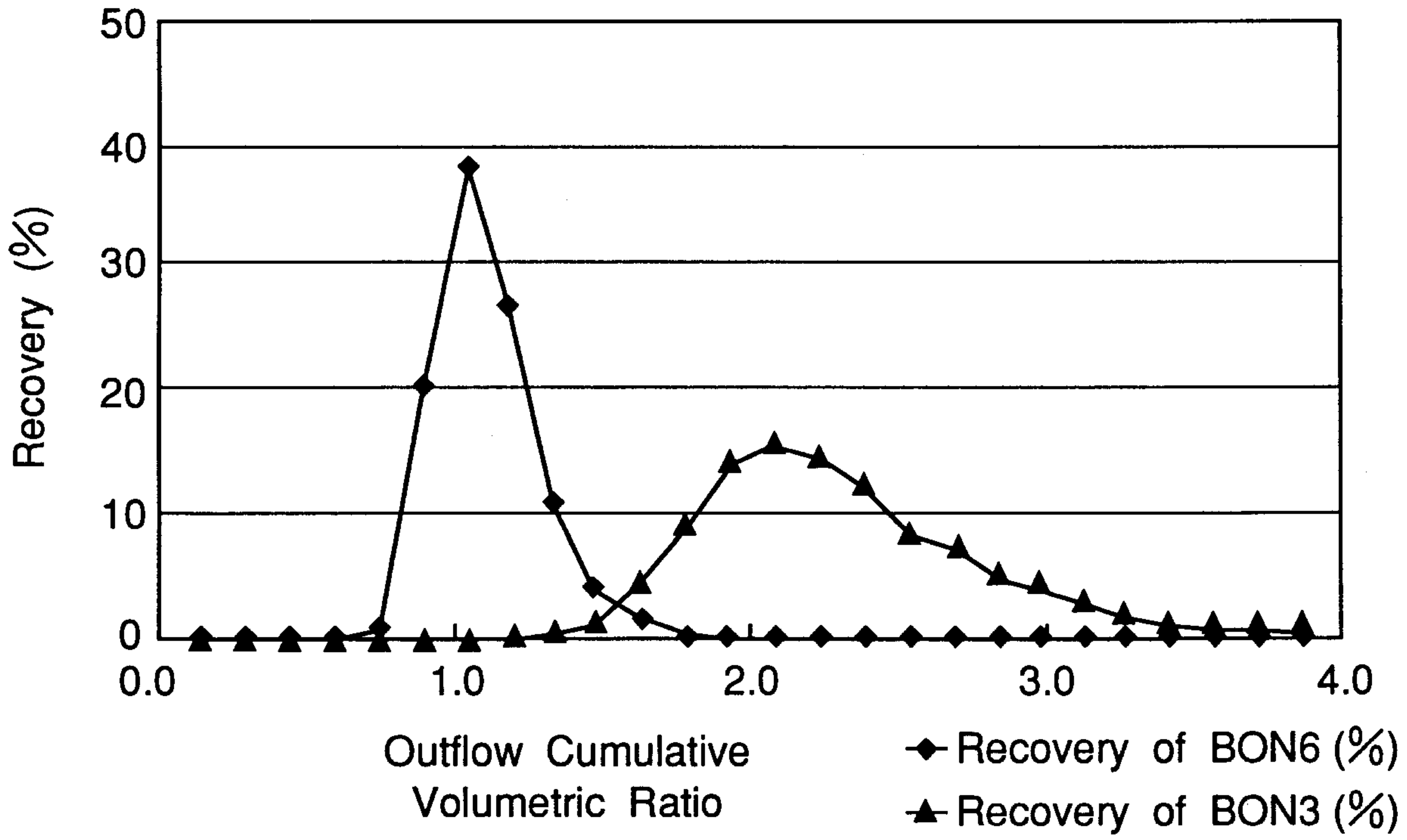

50
40
30
20
10
0
Recovery (%)
0.0
1.0
2.0
3.0
4.0
Outflow Cumulative
Volumetric Ratio
Recovery of BON6 (%)
Recovery of BON3 (%)

Fig.11

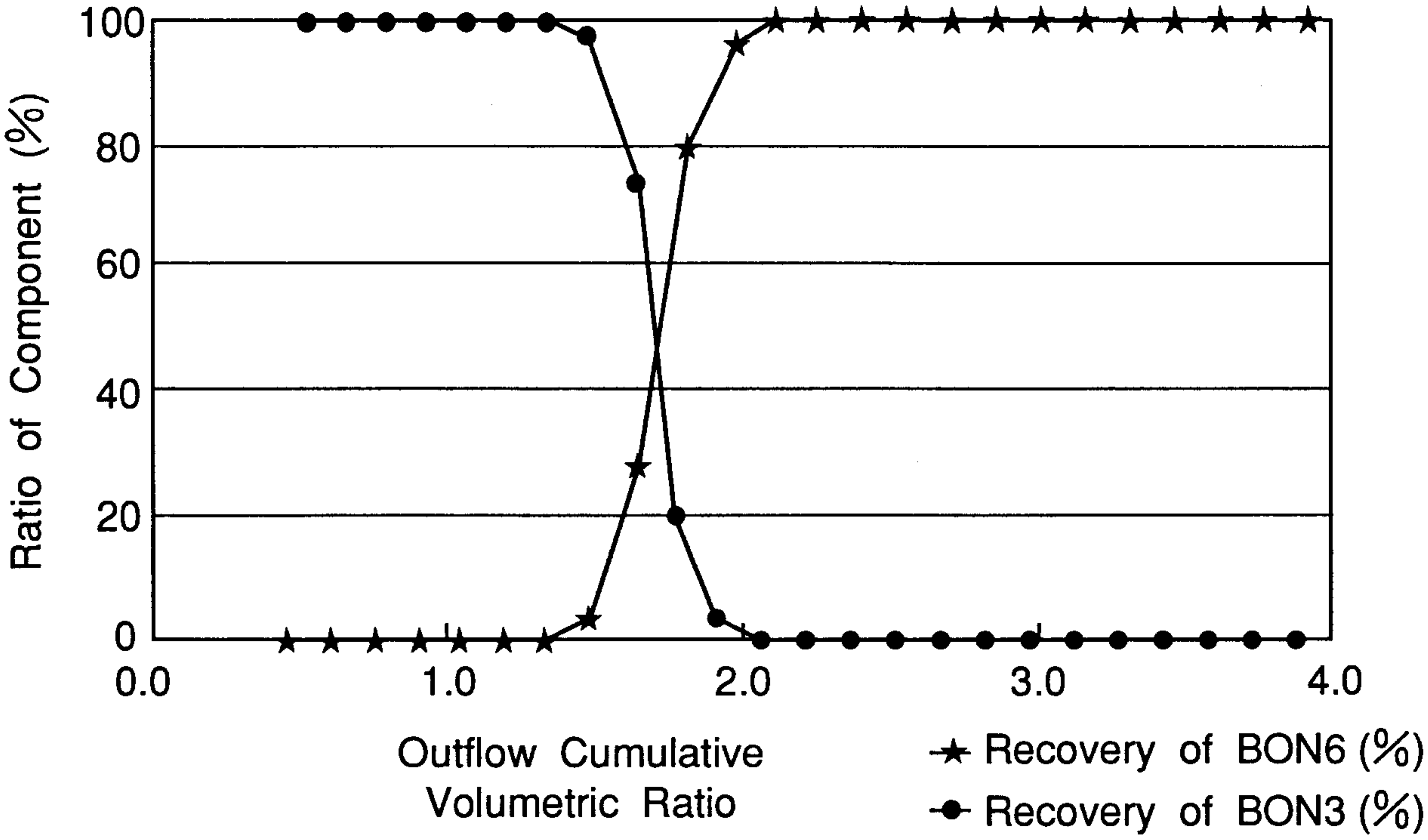

100
80
60
40
20
0
Ratio of Component (%)
0.0
1.0
2.0
3.0
4.0
Outflow Cumulative Volumetric Ratio
Recovery of BON6 (%)
Recovery of BON3 (%)

Fig.12

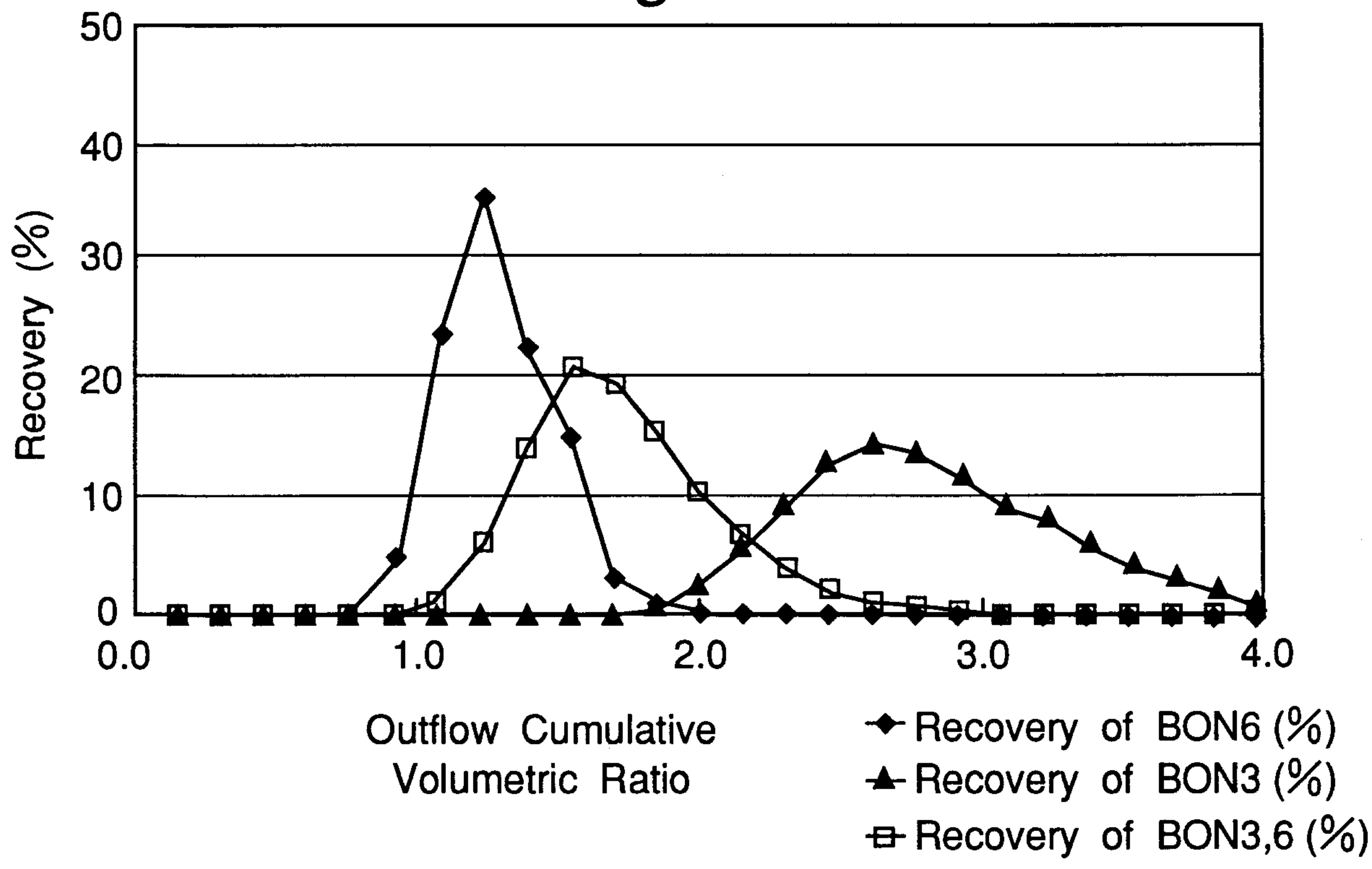
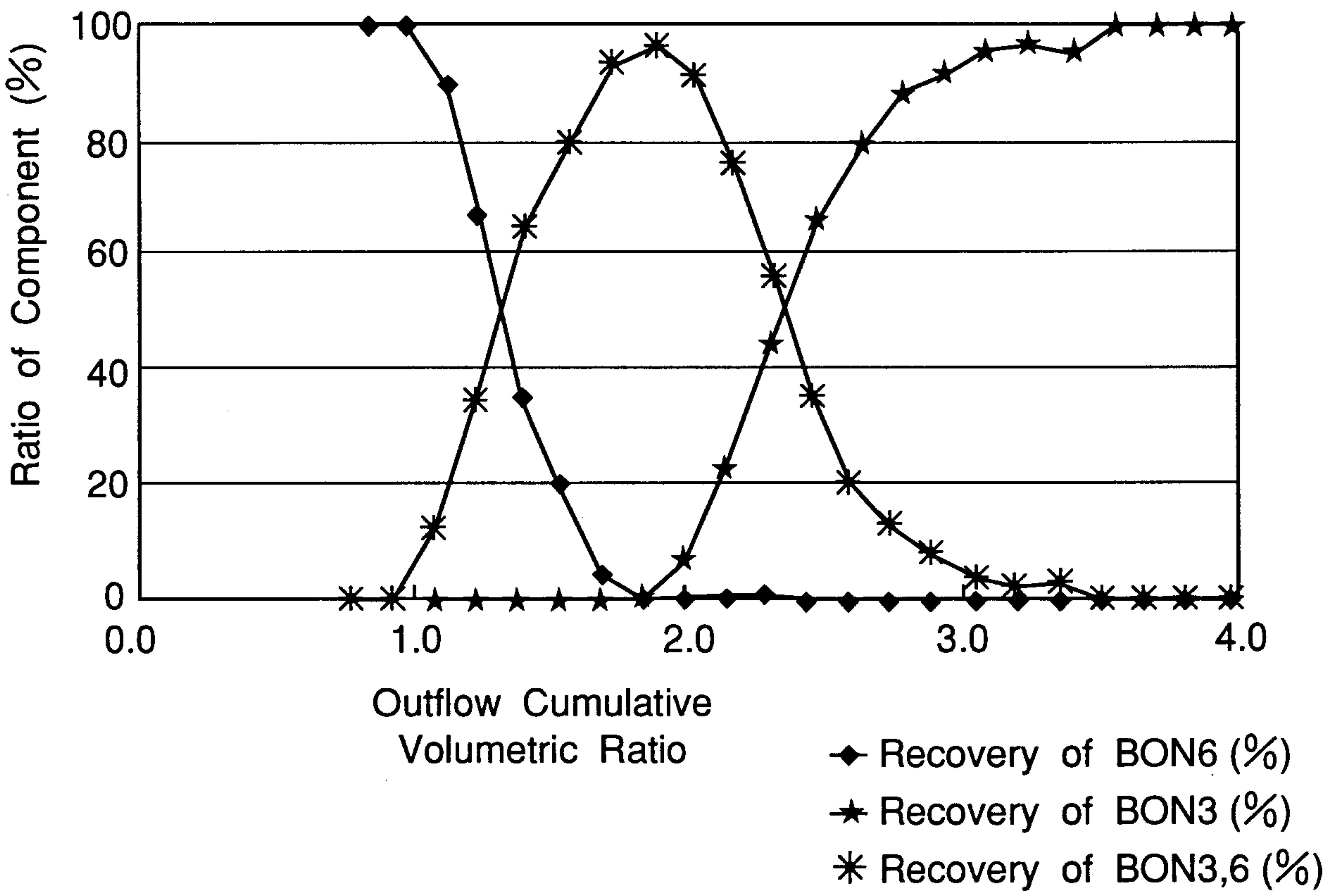

50
40
30
20
10
0
Recovery (%)
0.0
1.0
2.0
3.0
4.0
Outflow Cumulative Volumetric Ratio
Recovery of BON6 (%)
Recovery of BON3 (%)
Recovery of BON3,6 (%)

Fig.13


Ratio of Component (%)
100
80
60
40
20
0
0.0
1.0
2.0
3.0
4.0
Outflow Cumulative Volumetric Ratio
Recovery of BON6 (%)
Recovery of BON3 (%)
Recovery of BON3,6 (%)