

the stomach in rat. By means of intestinal recirculating perfusion method and ligated stomach method, the absorption of aminopyrine in rat was investigated to reaffirm. As shown in Table I, the absorption rate of the drug in the small intestine was much greater than that in the stomach. Consequently, it is probable that the absorption rate of aminopyrine may be related with the rate at which the drug leaves the stomach and enters into the duodenum, *i.e.* the gastric emptying rate. In consideration of the delay of maximum plasma concentration of aminopyrine due to higher dose, the gastric emptying rate is the most important factor. In a previous paper,^{1b)} it has been shown that the rate of gastric emptying of Phenol Red in rabbit decreased remarkably by aminopyrine. Fig. 3 showed the recovery of Phenol Red from the rat stomach as a function of time after simultaneous gastric intubation with aminopyrine. A distinct delay was also observed in the gastric emptying of Phenol Red in the presence of 50 mg/kg of aminopyrine. However, no variation was found measurably in the case of 20 mg/kg of aminopyrine as compared with the control rat (Phenol Red alone). For example, in the case of lower dose, 70% of Phenol Red was emptied within 0.5 hr, whereas in the case of higher dose, about 2 hr were necessary to empty the same amount of dye.

Therefore, it is concluded that in the case of 50 mg/kg of aminopyrine the delay of the time at which the peak level occurs is caused by the pharmacologic effect of aminopyrine which is the inhibition of gastric emptying to delay the transfer of aminopyrine itself, and that a gastric emptying may be the rate-limited step in the absorption.

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Synthesis of Tryptic Peptides of Hen Egg Lysozyme (Positions 1-5 and 69-73) and Related Peptides¹⁾

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Joullié, *et al*³⁾ have claimed that three tryptic peptides of hen egg lysozyme, H-Lys-Val-Phe-Gly-Arg-OH (positions 1-5), H-Thr-Pro-Gly-Ser-Arg-OH (positions 69-73) and H-Phe-Glu-Ser-Asn-Phe-Asn-Gln-Ala-Thr-Thr-Asn-Arg-OH (positions 34-45),⁴⁾ inhibited the action of histamine on isolated guinea pig ileum at a concentration of 1×10^{-7} g/ml.

In the present communication, we describe the synthesis of H-Lys-Val-Phe-Gly-Arg-OH, H-Lys-Val-Tyr-Gly-Arg-OH (amino terminal pentapeptide of turkey egg lysozyme),⁵⁾ its

- 1) Symbols for amino acid derivatives and peptides used in this text are those recommended by IUPAC-IUB Commission on Biochemical Nomenclature; *Biochem. J.*, **126**, 773 (1972). Other abbreviations: DCC=dicyclohexylcarbodiimide, DMF=dimethylformamide, CMC=carboxymethyl cellulose.
- 2) Location: *Komatsushima, Sendai, 983, Japan*; a) Present address: *Yoshitomi Seiyaku Co., Nihonbashi, Chuo-ku, Tokyo*.
- 3) M. Joullié, M. Laure, G. Maillard and P. Muller, Fr. Patent 1549157 (1968) [*C.A.* **72**, 3775d (1970)].
- 4) For the sequence according to J. Jolles, J. Jauregui-Adell, I. Bernier and P. Jolles, *Biochim. Biophys. Acta*, **78**, 668 (1963) read H-Phe-Glu-Ser-Asn-Phe-Asn-Thr-Gln-Ala-Thr-Asn-Arg-OH according to R. Canfield, *J. Biol. Chem.*, **238**, 2698 (1963) and R. Canfield and A.K. Liu, *ibid.*, **240**, 1998 (1965).
- 5) J.N. LaRue and J.C. Speck, Jr., *J. Biol. Chem.*, **245**, 1985 (1970).

related peptides, and H-Thr-Pro-Gly-Ser-Arg-OH to confirm their biological activity. For the synthesis of H-Lys-Val-Phe-Gly-Arg-OH, Z-Phe-Gly-ONp⁶⁾ was coupled with H-Arg(NO₂)-ONb derived from Z-Arg(NO₂)-ONb⁷⁾ to yield Z-Phe-Gly-Arg(NO₂)-ONb (I). I was treated with hydrogen bromide-acetic acid to remove the Z-group and the resulting tripeptide ester was coupled with Z-Val-ONp⁸⁾ to yield Z-Val-Phe-Gly-Arg(NO₂)-ONb (II). II was hydrogenated in 50% acetic acid over 5% Pd-carbon. The hydrogenated product was purified through CMC column to yield homogeneous H-Val-Phe-Gly-Arg-OH (III). Homogeneity of III was assessed by paper chromatography using two different solvent systems and amino acid analysis of the acid hydrolysate. Z-Lys(Z)-ONSu⁹⁾ was coupled with de-benzyloxycarbonylated II to yield Z-Lys(Z)-Val-Phe-Gly-Arg(NO₂)-ONb (IV). Catalytic hydrogenation of IV and the purification gave homogeneous H-Lys-Val-Phe-Gly-Arg-OH (V). Analogous chain elongation of Z-Gly-Arg(NO₂)-ONb¹⁰⁾ with Z-Tyr(Bzl)-ONp,¹¹⁾ Z-Val-ONp and Z-Lys(Z)-ONSu yielded Z-Tyr(Bzl)-Gly-Arg(NO₂)-ONb(VI), Z-Val-Tyr(Bzl)-Gly-Arg(NO₂)-ONb (VII) and Z-Lys(Z)-Val-Tyr(Bzl)-Gly-Arg(NO₂)-ONb (IX) respectively. Catalytic hydrogenation of VII and IX gave H-Val-Tyr-Gly-Arg-OH (VIII) and H-Lys-Val-Tyr-Gly-Arg-OH (X) respectively.

The azide prepared from Boc-Ser-NHNH₂¹²⁾ according to the procedure given by Rudinger, *et al.*¹³⁾ was coupled with H-Arg(NO₂)-OBzl ditosylate¹⁴⁾ to yield Boc-Ser-Arg(NO₂)-OBzl (XI). XI was treated with trifluoroacetic acid to remove the *tert*-butoxycarbonyl group and the resulting dipeptide ester was coupled with Boc-Gly-ONp¹⁵⁾ to yield Boc-Gly-Ser-Arg(NO₂)-OBzl (XII). Boc-Thr-OH¹⁵⁾ and H-Pro-OBzl·HCl¹⁶⁾ were coupled by DCC procedure to yield Boc-Thr-Pro-OBzl (XIII). XIII was treated with hydrazine hydrate to yield Boc-Thr-Pro-NHNH₂ (XIV) which was used for the next coupling reaction without further purification. The azide prepared from XIV was coupled with de-*tert*-butoxycarbonylated XII to yield Boc-Thr-Pro-Gly-Ser-Arg(NO₂)-OBzl (XV). XV was de-*tert*-butoxycarbonylated and hydrogenated to yield H-Thr-Pro-Gly-Ser-Arg-OH (XVI).

Anti-histaminic activity of III, V, VIII, X and XVI was assayed by Magnus method on isolated guinea pig ileum at concentration of 10⁻⁸ g/ml to 10⁻⁴ g/ml. None of these peptides inhibited the contraction due to 1 × 10⁻⁷ g/ml of histamine hydrochloride. The discrepancies between the results recorded in the present paper and in the literature³⁾ may presumably be explained by an assumption that the two tryptic peptides described in the literature may be contaminated with hen egg lysozyme itself which show anti-histaminic activity on isolated guinea pig ileum¹⁷⁾ or with hypothetical another active fragment(s) derived from lysozyme. On the other hand, V caused weak relaxation of a guinea pig ileum, *i.e.* V at a concentration of 1 × 10⁻⁴ g/ml caused 50% inhibition of the normal contraction due to 5 × 10⁻⁴ g/ml of BaCl₂.

Experimental

All melting points are uncorrected. Unless otherwise mentioned, Z-group of the protected amino acids and peptides were deblocked with HBr in AcOH and Boc-group with trifluoroacetic acid, and the

- 6) K. Suzuki and T. Abiko, *Chem. Pharm. Bull.* (Tokyo), **15**, 1212 (1967).
- 7) R.A. Boissonnas, St. Guttman and P.A. Jaquaenoud, *Helv. Chim. Acta*, **43**, 1349 (1960).
- 8) B. Iselin, W. Rittel, P. Sieber and R. Schwyzer, *Helv. Chim. Acta*, **40**, 373 (1957).
- 9) S. Chladek and J. Zemlicka, *Collect. Czech. Chem. Commun.*, **33**, 4299 (1968).
- 10) F.B. Abramson, D.F. Elliott, D.G. Lindsay and R. Wade, *J. Chem. Soc. (C)*, 1042 (1970).
- 11) M. Bodanszky and V. du Vigneaud, *J. Am. Chem. Soc.*, **81**, 2504 (1959).
- 12) B. Iselin and R. Schwyzer, *Helv. Chim. Acta*, **44**, 169 (1961).
- 13) J. Honzl and J. Rudinger, *Collect. Czech. Chem. Commun.*, **26**, 2333 (1961).
- 14) S. Sakakibara and N. Inukai, *Bull. Chem. Soc. Japan*, **39**, 1567 (1966).
- 15) E. Bayer, G. Jung and H. Hagenmaier, *Tetrahedron*, **24**, 4853 (1968).
- 16) R.E. Neuman and E.L. Smith, *J. Biol. Chem.*, **193**, 97 (1951).
- 17) J.-L. Parrot, G. Nicot, C. Laborde and P. Canu, *J. Physiol. (Paris)*, **54**, 739 (1962).

resulting amino components were chromatographed on filter paper, Toyo Roshi No. 51, at room temperature by ascending procedure. $R_f(A)$ values refer to Partridge system¹⁸⁾ and $R_f(B)$ values refer to the system of BuOH-pyridine-AcOH-H₂O (30:20:6:24).¹⁹⁾ The amino acid composition of the acid hydrolysates was determined with Hitachi Model KLA-3B amino acid analyzer according to the directions given by Moore, *et al.*²⁰⁾

Z-Phe-Gly-Arg(NO₂)-ONb (I)—Z-Arg(NO₂)-ONb (2.4 g) was dissolved in 2.6N HBr in AcOH (20 ml). After 50 min at room temperature, dry ether was added to the reaction mixture. The precipitate thereby formed was collected and dried over KOH pellets in vacuum. To a solution of this product in DMF (20 ml), Z-Phe-Gly-ONp (2.7 g) was added, followed by Et₃N to keep the solution slightly alkaline. After 24 hr at room temperature, the reaction mixture was diluted with 1N NH₄OH (3 ml) and stirred for 1 hr. The mixture was poured into cold 1N NH₄OH with stirring. To the suspension, 50% NH₄OAc was added dropwise with stirring to form precipitate. The precipitate was collected and washed successively with 1N NH₄OH, H₂O, 1N HCl and H₂O. The dried product was refluxed with EtOAc and collected on filter in hot; amorphous powder, yield 3.2 g (94%). For analysis a sample was reprecipitated from AcOH and H₂O, mp 98—108°; $[\alpha]_D^{25} - 15.5^\circ$ ($c=1.0$, DMF); de-Z peptide ester HBr salt, $R_f(A)$ 0.53, $R_f(B)$ 0.89, single ninhydrin positive spot; *Anal.* Calcd. for C₃₂H₃₆O₁₆N₈: C, 55.48; H, 5.24; N, 16.18. Found: 55.81; H, 5.31; N, 16.24.

Z-Val-Phe-Gly-Arg(NO₂)-ONb (II)—The compound was prepared from I (3.5 g) and Z-Val-ONp (2.0 g) essentially in the same manner as described above. The dried product was refluxed with EtOAc; amorphous powder, yield 3.1 g (78%). For analysis a sample was reprecipitated from AcOH and H₂O, mp 110—130°; $[\alpha]_D^{25} - 3.8^\circ$ ($c=1.0$, DMF); de-Z peptide ester HBr salt, $R_f(A)$ 0.79, $R_f(B)$ 0.93, single ninhydrin positive spot; *Anal.* Calcd. for C₃₇H₄₅O₁₁N₉: C, 56.12; H, 5.73; N, 15.92. Found: C, 55.59; H, 5.64; N, 15.82.

H-Val-Phe-Gly-Arg-OH (III)—The fully protected tetrapeptide II (300 mg) was hydrogenated in 50% AcOH (16 ml) over 5% Pd-C for 48 hr. The catalyst was removed by the aid of Cellite. The solution was evaporated to dryness and the residue was dried over KOH pellets in vacuum. The solution of the crude product in H₂O (10 ml) was added to a CMC column (2.0 × 15.0 cm) which was eluted with a linear gradient elution from H₂O (300 ml) in mixing chamber to 0.075M pyridinium acetate (pH 5.1, 300 ml) in reservoir. Fractions of 6 ml each were collected at a flow rate of 2 ml/min with an automatic fraction collector. The arginine-containing peptide was located in the eluate by Sakaguchi reaction. The eluates in tubes No. 28 to 35 containing the tetrapeptide were pooled, evaporated to dryness in vacuum and lyophilized; colorless fluffy material, yield 206 mg (91%); mp 130—146°; $[\alpha]_D^{25} + 0.3^\circ$ ($c=0.9$, H₂O); $R_f(A)$ 0.41, $R_f(B)$ 0.54, single ninhydrin and Sakaguchi positive spot; amino acid ratios in the acid hydrolysate: Val 1.03, Phe 0.97, Gly 0.97, Arg 1.01, (average recovery 83%).

Z-Lys(Z)-Val-Phe-Gly-Arg(NO₂)-ONb (IV)—The compound was prepared from II (388 mg) and Z-Lys(Z)-ONSu (282 mg) essentially in the same manner as described for the preparation of I. The dried product was reprecipitated from AcOH and H₂O; amorphous powder, yield 460 mg (89%); mp 115—135°; $[\alpha]_D^{25} - 27.8^\circ$ ($c=1.2$, DMF); the fully protected peptide, $R_f(A)$ 0.91, $R_f(B)$ 0.92, single chlorine positive spot; *Anal.* Calcd. for C₅₁H₆₃O₁₄N₁₁: C, 58.11; H, 6.02; N, 14.62. Found: C, 57.70; H, 6.12; N, 14.24.

H-Lys-Val-Phe-Gly-Arg-OH (V)—IV (200 mg) in 50% AcOH was hydrogenated in the usual manner for 48 hr. The hydrogenated product in H₂O (10 ml) was added to a CMC column (2.0 × 11.0 cm) which was eluted with a linear gradient elution from H₂O (300 ml) in mixing chamber to 0.7M pyridinium acetate (pH 5.1, 300 ml) in reservoir. Fractions of 6 ml each were collected at a flow rate 2 ml/min with an automatic fraction collector. The arginine-containing peptide was located in the eluate by Sakaguchi reaction. The eluates in tubes No. 66 to 72 containing the pentapeptide were pooled, evaporated to dryness in vacuum and lyophilized; colorless fluffy material, yield 55 mg (48%); mp 98—108°; $[\alpha]_D^{25} - 0.3^\circ$ ($c=0.6$, H₂O); $R_f(A)$ 0.33, $R_f(B)$ 0.65, single ninhydrin and Sakaguchi positive spot; amino acid ratios in the acid hydrolysate: Lys 1.02, Val 0.95, Phe 0.98, Gly 1.03, Arg 1.01, (average recovery 93%).

Z-Tyr(Bzl)-Gly-Arg(NO₂)-ONb (VI)—The compound was prepared from Z-Gly-Arg(NO₂)-ONb (532 mg) and Z-Tyr(Bzl)-ONp (579 mg) essentially in the same manner as described for the preparation of I. The dried product was refluxed with EtOAc; amorphous powder, yield 701 mg (88%). For analysis a sample was reprecipitated from AcOH and H₂O, mp 89—96°; $[\alpha]_D^{25} - 26.3^\circ$ ($c=1.6$, DMF); de-Z peptide ester HBr salt, $R_f(A)$ 0.58, $R_f(B)$ 0.83, single ninhydrin and Pauly positive spot; *Anal.* Calcd. for C₃₉H₄₂O₁₁N₃: C, 58.64; H, 5.31; N, 14.03. Found: C, 58.47; H, 5.24; N, 13.60.

Z-Val-Tyr(Bzl)-Gly-Arg(NO₂)-ONb (VII)—The compound was prepared from VI (395 mg) and Z-Val-ONp (197 mg) essentially in the same manner as described for the preparation of I; amorphous powder, yield 253 mg (56%). For analysis a sample was reprecipitated from AcOH and H₂O, mp 130—138°; $[\alpha]_D^{25} - 4.8^\circ$ ($c=1.1$, DMF); de-Z peptide ester HBr salt, $R_f(A)$ 0.69, $R_f(B)$ 0.91, single ninhydrin and Pauly positive spot; *Anal.* Calcd. for C₄₄H₅₁O₁₂N₉·H₂O: C, 57.69; H, 5.83; N, 13.76. Found: C, 57.46; H, 5.54; N, 13.97.

18) S.M. Partridge, *Biochem. J.*, **42**, 238 (1948).

19) S.G. Waley and G. Watson, *Biochem. J.*, **55**, 328 (1953).

20) S. Moore, D.H. Spackman and W.H. Stein, *Anal. Chem.*, **30**, 1185 (1958).

H-Val-Tyr-Gly-Arg-OH (VIII)—VII (200 mg) in 50% AcOH was hydrogenated in the usual manner for 48 hr. The hydrogenated product in H₂O (10 ml) was added to a CMC column (2.0 × 15.0 cm) which was eluted with a linear gradient elution from H₂O (300 ml) in mixing chamber to 0.05M NH₄OAc buffer (pH 6.50, 300 ml) in reservoir. Fractions of 6 ml each were collected at a flow rate of 2 ml/min with an automatic fraction collector and the absorbancy of each fraction was determined at 280 mμ. The eluates in tubes No. 74 to 79 containing the tetrapeptide were pooled, evaporated to dryness in vacuum and lyophilized. NH₄OAc was removed by repeated lyophilization to constant weight; colorless fluffy material, yield 95 mg (86%); mp 142—166°; $[\alpha]_D^{25} + 31.5^\circ$ ($c=0.9$, H₂O); *Rf*(A) 0.21, *Rf*(B) 0.40, single ninhydrin, Sakaguchi and Pauly positive spot; amino acid ratios in the acid hydrolysate: Val 0.97, Tyr 0.97, Gly 1.03, Arg 1.00, (average recovery 83%).

Z-Lys(Z)-Val-Tyr(Bzl)-Gly-Arg(NO₂)-ONb (IX)—The compound was prepared from VII (297 mg) and Z-Lys(Z)-ONSu (188 mg) essentially in the same manner as described for the preparation of I. The dried product was reprecipitated from AcOH and H₂O; amorphous powder, yield 235 mg (60%); mp 91—108°; $[\alpha]_D^{25} - 16.7^\circ$ ($c=0.8$, DMF); the fully protected peptide, *Rf*(A) 0.90, *Rf*(B) 0.93, single chlorine and Pauly positive spot; *Anal.* Calcd. for C₅₈H₆₉O₁₅N₁₁·H₂O: C, 59.12; H, 6.07; N, 13.08. Found: C, 59.23; H, 5.92; N, 12.99.

H-Lys-Val-Tyr-Gly-Arg-OH (X)—IX (150 mg) in 50% AcOH was hydrogenated in the usual manner for 48 hr. The hydrogenated product in H₂O (10 ml) was added to a CMC column (2.0 × 15.0 cm) which was eluted with a linear gradient elution from H₂O (300 ml) in mixing chamber to 0.5M NH₄OAc buffer (pH 6.50, 300 ml) in reservoir. Fractions of 6 ml each were collected at a flow rate of 2 ml/min with an automatic fraction collector and the absorbancy of each fraction was determined at 280 mμ. The eluates in tubes No. 49 to 53 containing the pentapeptide were pooled, evaporated to dryness in vacuum and lyophilized. NH₄OAc was removed by repeated lyophilization to constant weight; colorless fluffy material, yield 61 mg (75%); mp 133—168°; $[\alpha]_D^{25} - 9.7^\circ$ ($c=0.9$, H₂O); *Rf*(A) 0.13, *Rf*(B) 0.31, single ninhydrin, Sakaguchi and Pauly positive spot; amino acid ratios in the acid hydrolysate: Lys 1.00, Val 0.98, Tyr 0.92, Gly 1.05, Arg 1.04, (average recovery 98%).

Boc-Ser-Arg(NO₂)-OBzl (XI)—A solution of Boc-Ser-NHNH₂ (470 mg) in DMF (10 ml) was chilled in dry ice-80% EtOH bath to -60°. To this solution, 4N HCl in dioxane (2.13 ml) was added, followed by isoamyl nitrite (0.24 ml). The mixture was stirred for 20 min until hydrazine test was negative. The mixture was neutralized with Et₃N (1.4 ml) at -60°. H-Arg(NO₂)-OBzl ditosylate (1.31 g) in DMF (5 ml) was neutralized with Et₃N and chilled in an ice bath. To a cold solution of the amino acid ester, a cold solution of the Boc-amino acid azide described above was added and stirred at 5° for 48 hr and at room temperature for 1 hr. The mixture was diluted with H₂O (50 ml) and extracted with EtOAc. The EtOAc layer was washed successively with 1N NaHCO₃, H₂O, 1N citric acid and H₂O. The EtOAc solution was dried over MgSO₄ and concentrated to a small volume in vacuum. Petroleum ether was added to the residue and the precipitate thereby formed was recrystallized from EtOAc and petroleum ether; needles, yield 470 mg (47%); mp 80—115°; $[\alpha]_D^{25} - 27.3^\circ$ ($c=1.1$, DMF); de-Boc derivative, *Rf*(A) 0.65, *Rf*(B) 0.83, single ninhydrin positive spot; *Anal.* Calcd. for C₂₁H₃₂O₈N₆: C, 50.80; H, 6.50; N, 16.93. Found: C, 51.02; H, 6.47; N, 16.72.

Boc-Gly-Ser-Arg(NO₂)-OBzl (XII)—XI (400 mg) was treated with trifluoroacetic acid for 20 min at room temperature and the mixture was added dry ether. The precipitate thereby formed was collected by centrifugation and dried over KOH pellets in vacuum. To the solution of this dipeptide ester in DMF (2 ml), Boc-Gly-ONp (240 mg) and Et₃N (0.12 ml) were added. After 24 hr, the reaction mixture was diluted with 1N NH₄OH (0.5 ml) and stirred for 1 hr. The mixture was diluted with EtOAc and the EtOAc layer was washed successively with 1N NH₄OH, H₂O, 1N citric acid and H₂O which were mixed with equal volume of saturated NaCl. The EtOAc solution was dried over MgSO₄ and evaporated to dryness; yield 316 mg (71%). For analysis a sample was reprecipitated from acetone and ether, mp 70—75°; $[\alpha]_D^{25} - 9.1^\circ$ ($c=0.3$, DMF); de-Boc derivative, *Rf*(A) 0.65, *Rf*(B) 0.85, single ninhydrin positive spot; *Anal.* Calcd. for C₂₃H₃₅O₉N₇·H₂O: C, 48.33; H, 6.53; N, 17.15. Found: C, 48.67; H, 6.28; N, 17.20.

Boc-Thr-Pro-OBzl (XIII)—To a solution of H-Pro-OBzl·HCl (4.83 g) in DMF (16 ml), Boc-Thr-OH (4.39 g) was added, followed by Et₃N (2.8 ml). The mixture was chilled in an ice bath and N-hydroxy-succinimide (2.3 g) was added, followed by DCC (4.54 g). After 20 hr at 0° and 2 hr at room temperature, a few drops of AcOH was added. Dicyclohexylurea thereby formed was removed by filtration. EtOAc was added to the filtrate and the EtOAc solution was washed successively with 1N NaHCO₃, H₂O, 1N citric acid and H₂O. The EtOAc solution was dried over MgSO₄ and evaporated to dryness. The residue was crystallized from EtOAc and petroleum ether; needles, yield 3.64 g (45%); mp 104—104.5°; $[\alpha]_D^{25} - 52.6^\circ$ ($c=1.1$, DMF); de-Boc derivative, *Rf*(A) 0.79, *Rf*(B) 0.86, single ninhydrin positive spot; *Anal.* Calcd. for C₂₁H₃₀O₆N₂: C, 62.05; H, 7.44; N, 6.89. Found: C, 61.87; H, 7.56; N, 7.05.

Boc-Thr-Pro-NHNH₂ (XIV)—XIII (200 mg) in MeOH (1 ml) was added hydrazine hydrate (0.25 ml) and stirred overnight at room temperature. The mixture was evaporated in vacuum and the residue was dried over conc. H₂SO₄ in vacuum. The fully protected compound, *Rf*(A) 0.81, *Rf*(B) 0.96, hydrazine test positive spot. The product was used without further purification.

Boc-Thr-Pro-Gly-Ser-Arg(NO₂)-OBzl (XV)—A solution of XIV (200 mg) in DMF (3 ml) was chilled in dry ice-80% EtOH bath to -60°. To this solution, 4N HCl in dioxane (1.25 ml) was added, followed

by isoamyl nitrite (0.09 ml) and the mixture was stirred for 20 min until hydrazine test was negative. The mixture was neutralized with Et_3N (0.70 ml) at -60° . XII (276 mg) was treated with trifluoroacetic acid (1.3 ml) for 20 min as described above. The resulting tripeptide ester trifluoroacetate in DMF (3 ml) was neutralized with Et_3N (0.07 ml) and chilled in an ice bath. To a cold solution of the peptide ester, a cold solution of the dipeptide azide described above was added and stirred at 5° for 24 hr and at room temperature for 1 hr. The reaction mixture was diluted with saturated NaCl and EtOAc. The EtOAc layer was washed and treated as described for the preparation of XII. The resulting oily residue was scratched with ether to give fine powder, yield 251 mg (55%). For analysis a sample was reprecipitated from acetone and ether, mp $101-112^\circ$; $[\alpha]_D^{25} -18.3^\circ$ ($c=0.6$, DMF); de-Boc derivative, $R_f(\text{A})$ 0.59, $R_f(\text{B})$ 0.81, single ninhydrin positive spot; *Anal.* Calcd. for $\text{C}_{32}\text{H}_{49}\text{O}_{12}\text{N}_9 \cdot 2\text{H}_2\text{O}$: C, 48.78; H, 6.78; N, 16.00. Found: C, 48.55; H, 6.26; N, 16.40.

H-Thr-Pro-Gly-Ser-Arg-OH (XVI)—XV (104 mg) was treated with trifluoroacetic acid (1.5 ml) for 20 min at room temperature. The mixture was diluted with dry ether. The precipitate thereby formed was collected by centrifugation, washed with dry ether and dried over KOH pellets in vacuum. The product was hydrogenated in a mixture of H_2O (25 ml) and AcOH (5 ml) for 24 hr in the presence of 5% Pd-C. The hydrogenated product was treated essentially in the same manner as described for the preparation of III. CMC column (2.0×10.0 cm) was eluted with a linear gradient elution from H_2O (300 ml) in mixing chamber to 0.13M pyridinium acetate (pH 5.1, 300 ml) in reservoir. The eluates in tubes No. 33 to 44 were pooled, evaporated in vacuum and lyophilized; colorless fluffy material, yield 51 mg (58%); mp $122-136^\circ$; $[\alpha]_D^{25} -48.5^\circ$ ($c=0.3$, H_2O); $R_f(\text{A})$ 0.17, $R_f(\text{B})$ 0.30, single ninhydrin and Sakaguchi positive spot; amino acid ratios in the acid hydrolysate: Thr 0.98, Pro 1.02, Gly 1.02, Ser 1.00, Arg 0.98, (average recovery 74%).

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Purines. XVI.¹⁾ One-Step Alkylation of Adenine 1-Oxide Leading to 1-Alkoxy-9-alkyladenine Hydriodide²⁾

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Previous reports^{4,5)} from this laboratory described the facile synthesis of 1-alkoxy-9-alkyladenine salts (type III·HX) from adenine 1-oxide (I) *via* 1-alkoxyadenines (type II) or from 9-alkyladenine 1-oxides (type IV). The route starting with I consists of three steps (Chart 1),^{4a,b)} *i.e.*, alkylation of I with an alkyl halide in *N,N*-dimethylacetamide (DMAC) to give 1-alkoxyadenine salt (II·HX), conversion of II·HX into the corresponding free base (II), and the second alkylation of the base (II) at the 9-position under similar alkylation

- 1) Paper XV in this series, T. Fujii, F. Tanaka, K. Mohri, and T. Itaya, *Chem. Pharm. Bull.* (Tokyo), **22**, 2211 (1974).
- 2) Presented in part at the 37th Meeting of Hokuriku Branch, Pharmaceutical Society of Japan, Toyama, October 27, 1973.
- 3) Location: 13-1 Takara-machi, Kanazawa 920, Japan.
- 4) a) T. Fujii, T. Itaya, and S. Yamada, *Chem. Pharm. Bull.* (Tokyo), **13**, 1017 (1965); b) T. Fujii and T. Itaya, *Tetrahedron*, **27**, 351 (1971); c) *Idem*, *Chem. Pharm. Bull.* (Tokyo), **19**, 1611 (1971).
- 5) a) T. Fujii, C.C. Wu, T. Itaya, and S. Yamada, *Chem. Ind.* (London), **1966**, 1598; b) T. Fujii, C.C. Wu, and T. Itaya, *Chem. Pharm. Bull.* (Tokyo), **19**, 1368 (1971); c) T. Fujii, C.C. Wu, T. Itaya, S. Moro, and T. Saito, *ibid.*, **21**, 1676 (1973).