absorption, and the IR spectrum was identical with that of the sample prepared from 5-bromouracil,[6] mp 212–213 °C.

Anal. Calcd for $C_5H_6N_2O_3Br_2$: C, 19.89; H, 2.00; N, 9.48; Br, 52.93. Found: C, 19.99; H, 2.00; N, 9.60; Br, 52.73.

1-(2-Butanon-3-yl)-5-bromouracil (7). A. A solution of **6** (1 g, 8.9 mmol) in a mixture of triethylamine (1 g, 9.9 mmol) and 2-butanone (30 mL) was allowed to stand at 37 °C overnight. Crystals of triethylamine hydrobromide were precipitated. The mixture was condensed to dryness, and after the amine hydrobromide was removed by washing with water the residue was crystallized from propanol: yield 276 mg; mp 210–212 °C; UV λ_{max} (MeOH) 280 nm (ϵ 16 600); NMR (Me_2SO-d_6–D_2O) δ 2.16 (s, 3 H, CH_3CO), 2.53 (d, 3 H, CH_3CH, J = 7 Hz), 4.97 (q, 1 H, CH_3CH, J = 7 Hz), 8.04 (s, 1 H, C_6H); MS *m/e* 262 and 260 (M^+), 219 and 217 ($M^+ - CH_3CO$).

Anal. Calcd for $C_8H_9N_2O_3Br$: C, 36.80; H, 3.47; N, 10.73; Br, 30.61. Found: C, 36.90; H, 3.51; N, 10.68; Br, 30.20.

B. A solution of 5-bromouracil (382 mg, 2 mmol), 3-bromo-2-butanone (400 mg, 2.5 mmol), and triethylamine (1 mL) in DMF (20 mL) was allowed to stand at 37 °C overnight. Evaporation of the solvent and crystallization of the residue afforded 417 mg of **7**.

The IR spectra of the samples obtained by these two methods were the same.

1-[Bis(ethoxycarbonyl)methyl]-5-bromouracil (8). A. A solution of **6** (602 mg, 2 mmol), diethyl malonate (400 mg, 2.5 mmol), and triethylamine (1 mL) in DMF (10 mL) was allowed to stand at room temperature overnight and was concentrated to dryness. The residue was distributed between $CHCl_3$ and water, with the organic layer being taken. Silica gel chromatography eluting with a mixture of benzene and ethyl acetate (1–2:1) afforded 344 mg of a syrup, which gradually changed to crystals melting at 108–111 °C: UV λ_{max} (MeOH) 276 nm (ϵ 9100); NMR ($CDCl_3$–D_2O) δ 2.33 (t, 6 H, $2CH_3CH_2$, J = 7 Hz), 4.33 (q, 4 H, $2CH_3CH_2$, J = 7 Hz), 6.08 (s, 1 H, $CH(COOC_2H_5)_2$), 7.82 (s, 1 H, C_6H); MS *m/e* 450 and 348 (M^+), 277 and 275 ($M^+ - C_2H_5OCO$), 232 and 230 ($M^+ - C_2H_5OCO - C_2H_5O$, base peak).

Anal. Calcd for $C_{11}H_{13}N_2O_6Br$: C, 37.84; H, 3.75; N, 8.03; Br, 22.89. Found: C, 37.99; H, 3.83; N, 8.05; Br, 22.71.

B. A solution of **4** (382 mg, 2 mmol), diethyl bromomalonate (600 mg, 2.85 mmol), and triethylamine (1 mL) in DMF (20 mL) was allowed to stand at 37 °C overnight, and the product was isolated as mentioned in method A, yield 622 mg.

The IR spectra of the samples obtained by these two methods were the same.

Registry No.—**1**, 16350-59-7; **2**, 16350-60-0; **3**, 16417-11-1; **4**, 51-20-7; **6**, 28743-58-0; **7**, 66449-45-4; **8**, 66449-35-2; uracil, 66-22-8; chloromethyl methyl ether, 107-30-2; methanesulfenyl chloride, 5813-48-9; 2-butanone, 78-93-3; 3-bromo-2-butanone, 814-75-5; diethyl malonate, 105-53-3; diethyl bromomalonate, 685-87-0.

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Communications

Reaction of Alkyl Halides and Alkyl Methyl Ethers with Nitronium Tetrafluoroborate in Acetonitrile

Summary: The reaction of alkyl halides and alkyl ethers with nitronium tetrafluoroborate in acetonitrile affords acetamides by electrophilic cleavage of the carbon–heteroatom bond and trapping the resulting trivalent carbenium ion with acetonitrile.

Sir: The electron-deficient nitronium ion interacts strongly with π systems and has been used extensively in aromatic nitration. Nitronium salts are also powerful oxidizing agents as evidenced by their substitution (nitration) and cleavage (nitrolysis) of σ-donor single bonds in hydrocarbons.[1] The heterolytic cleavage of C–C and C–H bonds has been observed in low yield with NO_2PF_6 in aprotic solvents.[2] More recently, we have found that NO_2BF_4 in acetonitrile will abstract hydride ion from a variety of hydrocarbons affording transient trivalent carbenium ions.[3]

In addition to the reaction of nitronium ion reagents with aromatic compounds, alkenes, and hydrocarbons, there have been several reports on the reaction of alkyl halides with nitronium ion.[4] Nascent nitronium ion, generated in situ by the reaction of hydrogen halide with nitric acid, was postulated to transform an alkyl iodide into a carbenium ion which was subsequently captured by halide and nitrate ions. Primary alkyl chlorides and alkyl fluorides were shown to be resistant to further reaction.[4] More recently, Olah has reported the oxidation of alkyl methyl ethers to carbonyl compounds in good yield utilizing nitronium tetrafluoroborate in dichloromethane solvent (eq 1).[5]

$$R_2CHOMe + NO_2^+BF_4^- \xrightarrow{CH_2Cl_2} \xrightarrow{H_2O} R_2C{=}O + CH_3OH \quad (1)$$

We now report a novel convenient procedure for the conversion of selected alkyl halides and alkyl methyl ethers to their corresponding acetamides. Our results, which are summarized in Table I, demonstrate the utility and limitations of this reaction for electrophilic attack on lone pair donor molecules.

The experimental procedure is extremely easy to carry out. In a typical experiment 10 mmol of substrate in 20 mL of dry CH_3CN was added to 13–20 mmol of NO_2BF_4 under a nitrogen atmosphere.[6,7] After stirring at room temperature for 1–15 h (Table I) the reaction was quenched by the addition of water and the acetamide product was isolated by simple extraction (Scheme I). The alkyl iodides, bromides, and methyl ethers were sufficiently reactive to warrant addition of the substrate at 0 °C. These highly exothermic reactions were allowed to stir 15 min at 0 °C and an additional 1–6 h at room temperature. The reactivity trends noted were RI > RBr ~ ROMe ≫ RH ~ RCl > RF.[8] In general, the ease of the abstraction of X^- or

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Table I. Reaction of Alkyl Halides and Alkyl Methyl Ethers with $NO_2^+BF_4^-$ in CH_3CN Solvent

$$RX + NO_2BF_4 \xrightarrow{CH_3CN} RNHCOCH_3$$

structure (RX)	X	reaction time h	% acetamide isolated[a]
1-adamantyl	I	1.5	94
	Br	5	82 (85)[b]
	Cl	6	90
	F	15	85
	OCH_3	2	88
	OEt	2	88
	O-*n*-Pr	2	92
tert-butyl	I	2	61
	Br	2	81
	Cl	2	— (88)[c]
	OCH_3	6	77
exo-norbornyl	I	1.5	89
	Br	3.3	50 (80)[d]
	Cl	15	72
	OCH_3	3	62
cyclohexyl	I	1.67	71
	Br	21	51 (57)[e]
n-butyl	I	1.67	— (62)[f]
2-propyl	Br	4	44[g]
	I	1.5	— (57)

[a] Isolated yields obtained after a single recrystallization from pentane/methylene chloride. The yields given in parentheses were measured by gas chromatography. [b] Triphenylmethane was utilized as the internal standard. [c] Utilizing 1 equiv of NO_2BF_4 afforded a bicomponent mixture: 83% of *tert*-butylacetamide plus 5% of 1-nitro-2-methyl-2-acetamidopropane. [d] Utilized benzophenone as the internal standard. [e] Cyclodecane was used as the internal standard. [f] GC yield using pentadecane as the internal standard. A bicomponent mixture consisting of *N*-(1-butyl)-acetamide (25%) and *N*-(2-butyl)acetamide (37%) was observed. [g] Pentadecane was used as the internal standard.

Scheme I

$$R_3CX + NO_2^+BF_4^- \longrightarrow R_3C^+ + NO_2X$$

$$R_3C^+ \xrightarrow{CH_3CN} R_3CN{\equiv}CCH_3 \xrightarrow{H_2O} R_3CN(H)C(=O)CH_3$$

X = H, Br, Cl, F, OCH_3

RO^- paralleled the stability of the resulting carbenium ions (i.e., tertiary > secondary > primary). For practical purposes, primary and secondary alkyl fluorides and chlorides are unreactive under these conditions. The best results were obtained with the adamantyl compounds where even adamantyl fluoride afforded a high yield of acetamide product.

We have also demonstrated that the ether cleavage reaction is not restricted to methyl ethers. The ethyl and *n*-propyl ethers of adamantane afforded 1-acetamidoadamantane in high yield (Table I). However, ethers with secondary alkyl substituents can result in a mixture of products in compliance with the reaction given in eq 1.[10] We have also extended the reaction to include other nitriles. This synthetic procedure may be applied to the synthesis of hindered amides if more highly substituted (saturated) nitriles are employed as solvents or as co-solvents with methylene chloride. For example, adamantyl bromide afforded *N*-(1-adamantyl)isobutyramide (76%) and adamantyl methyl ether was converted to *N*-(1-adamantyl)trimethylacetamide (55%) when isobutyro- and trimethylacetonitrile were used as solvents.

We suggest a mechanism (Scheme I) that involves an initial Lewis acid–Lewis base reaction of NO_2^+ with the nonbonding electron pairs of the halogen or ether oxygen to form a nitronium intermediate that suffers heterolysis of the C–X bond. Supporting evidence for a nitro–bromonium complex comes from our observation[11] that similar reaction of (1*R*,2*R*,4*S*)-(−)-2-bromonorbornane afforded racemic *N*-(*exo*-2-norbornyl)acetamide. These data demand a symmetrical (cationic) intermediate along the reaction pathway. The formation of both *N*-(1-butyl)- and *N*-(2-butyl)acetamides in the reaction of *n*-butyl iodide (Table I) also requires a 1,2-hydride transfer to a positive center. Acetonitrile solvent performs the function of a highly efficient carbenium ion trap affording a "Ritter type"[12] intermediate which affords acetamide products upon hydrolytic work-up. The only prior example of this reaction utilized a mixture of concentrated H_2SO_4 and HNO_3 to generate the acetamide from 1-bromoadamantane in acetronitrile.[13] We attribute the overall success of the present study to the relatively mild reaction conditions utilized, which impeded further oxidative reaction of the nitrilium ion intermediate.

In conclusion, we have provided a novel method for the cleavage of alkyl ethers and halides to their corresponding amides. Direct reduction of the amides with lithium aluminum hydride is readily achieved providing a synthesis of substituted amines.

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Synthesis of Imidazo[1,5-*a*]-1,3,5-triazinones by Cyclization–Rearrangement

Summary: A novel rearrangement has been utilized for the synthesis of imidazo[1,5-*a*]-1,3-5-triazinones which are analogues of 9-substituted hypoxanthines and guanines.

Sir: A strong case has been made for the desirability of synthesis and biological evaluation of nucleosides and nucleotides of guanine analogues.[1] We have discovered an originally un-

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