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Ozone Reactions
in Aqueous Solutions --
A Bibliography

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Ozone Reactions in Aqueous Solutions -- A Bibliography

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NBS special publication

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OZONE REACTIONS IN AQUEOUS SOLUTIONS

-- A BIBLIOGRAPHY

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A reaction oriented list of references is provided for published papers and reports containing rate data or information on mechanism for reactions of ozone with various substrates in aqueous solutions. Catalyzed, as well as uncatalyzed, reactions are included. One hundred and sixty-four papers are listed. The period covered extends from 1913 to 1981.

Key words: aqueous solution; bibliography; chemical kinetics; decomposition; mechanism; oxidation; ozone; rate constant; reaction.

This bibliography lists papers and reports on the reactions of ozone with various substrates in aqueous solutions. Catalyzed reactions, as well as uncatalyzed reactions, are included.

The first study of ozone reactions in aqueous solutions was performed in 1913 by V. Rothmund and A. Burgstaller, who studied the rate of decomposition of ozone in water. In 1917 the same authors studied the reaction between ozone and hydrogen peroxide. The study of ozone decomposition in water was continued by F. Kawamura (1932), K. Sennewald (1933), F. Weiss (1935), W. C. Bray (1938), and H. Taube and W. C. Bray (1940). H. Taube examined the reactions of ozone with formic acid (1941), with bromide ion (1942) and chloride ion (1949). Ozone decomposition was studied again by M. C. Alder and G. R. Hill (1950), W. Stumm (1954), E. Abel (1955), and Kilpatrick et al. (1956), while E. Abel studied also the reaction of ozone with hydrogen peroxide. Since 1970 there has been a large increase in the number of papers published in this subject area. The present bibliography includes 164 papers and reports dealing with such reactions. The period covered extends from 1913 to 1981.

GUIDELINES FOR THE USER

ARRANGEMENT OF THE REPORT

This bibliography is in two parts:

Part I. Guide to data contained in references. Each entry consists of a reference code and a property code. These are discussed below.

Part II. References

Ordering of Entries

In both parts of this report, entries are ordered chronologically beginning with the earliest papers and within each year alphabetically by author's name.

Reference Code

Each paper or report included in Part I is indicated by a brief reference code consisting of a string of characters showing:

- 1) Year of publication (last two digits)
- 2) Author or first two authors, using the first three letters of each last name (patronymic). When two names are present they are separated by a slash.
- 3) If necessary, a digit is added to distinguish among papers that would have the same code according to rules (1) and (2).

Examples:

42 TAU
70 SHA/KOZ
72 IVA/NIK
72 IVA/NIK2

The total length of the string, including the digit, may be no longer than 11 characters. A code without added digit has, implicitly, the digit 1 associated with it.

Property Code

The property code follows the reference code for each entry in Part I. The code consists of abbreviations which are used for data flagging. In this publication only the following listed four abbreviations are used for data flagging:

Dec (Decomposition)
Mec (Mechanism)
RR (Reaction Rate Data as: Rate constant, relaxation time, etc.)
Rxn with: (Reaction with other compounds)

References

Part II includes the same reference codes (or "short references") as Part I, in the same order, followed by the complete reference which gives: the name of author(s), the full title of the paper, and the name of the journal followed by the volume number, page, and year of publication. The full reference format is demonstrated below:

50 ALD/hLL Alder, M. G., and Hill, G. A., "The Kinetics and Mechanism of Hydroxide Ion Catalyzed Ozone Decomposition in Aqueous Solution," J. Am. Chem. Soc. 72, 1884 (1950).

Part I. Guide to Data Contained in References.

For explanation of reference codes and property codes used see Guidelines for the User.

13 ROT/BUR	Dec, RR
17 ROT/BUR	Rxn with: H_2O_2 ; RR
32 KAW	Dec, RR
33 SEN	Dec, RR
34 KAW	Dec, RR
35 WEI	Dec, Rxn with: H_2O_2 ; RR
37 VAS/KAS	Rxn with: $SO_2 + H_2O$; Mec, RR
38 BRA	Rxn with: H_2O_2 ; RR
40 TAU/BRA	Rxn with: H_2O_2 ; Mec, RR
41 TAU	Rxn with: $HCOOH$; Mec, RR
42 TAU	Rxn with: Br^- , Mec, RR
48 HIL	Rxn with: CO^{2+} ; Mec, RR
49 YEA/TAU	Rxn with: Cl^- ; RR
50 ALD/HIL	Dec, Mec, RR
54 STU	Dec, RR
55 ABE	Dec, Mec
55 ABE2	Rxn with: H_2O_2 ; Mec, RR
56 KIL/HER	Dec, RR
58 KLE/NAL	Rxn with: CH_3OOH ; RR
59 KHA/BAR	Rxn with: CN^- ; RR
61 SON/DOD	Rxn with: CN^- ; Mec
62 RAU/SII	Dec, RR
65 CON/HAM	Rxn with: Fe^{+2} ; RR
67 LUN/KUS	Rxn with: NO_2^- , SeO_3^{2-} , AsO_3^{3-} , PO_3^{3-} , Ag^+ , Mn^{2+} ; Mec
67 WAG/ECK	Rxn with: Cu^{2+}
68 CZA/SAM	Dec, RR
68 EIS	Rxn with: C_6H_5-OH ; Mec
68 GRI/SHA	Rxn with: $N_2H_5^+$ salts; Mec
68 ILN/KHE	Rxn with: Pyrenes and Anthracenes
68 SEN/IKE	Rxn with: Mn^{2+}
70 LUN/FRA	Rxn with: NO_2^- , HPO_3^{2-} , SeO_3^{2-} ; Mec

70 KAN/MOK Rxn with: $\text{cy-C}_6\text{H}_{12}$; Mec
 70 ROG Dec, RR
 70 SHA/KOZ Rxn with Np(VI) ; RR
 71 EIS Rxn with: $\text{C}_6\text{H}_5\text{OH}$; Mec
 71 HEW/DAV Dec, RR
 71 MER/LOV Dec, RR
 71 ROG Rxn with: $(\text{CH}_3)_2\text{NH}$
 71 SHE/MAR Rxn with: Phosphanamide
 71 VYA/DAV Rxn with: Pu(IV)
 72 BAL/SEL Rxn with: CN^- ; RR
 72 DON/EHR Rxn with: Carbon black; Mec
 72 GOU Rxn with: $\text{C}_6\text{H}_5\text{OH}$; RR, Mec
 72 IVA/NIK Dec, RR, Mec
 72 IVA/NIK2 Rxn with: Ce^{3+} , Ag^+ ; RR, Mec
 72 KRI/MUR Rxn with: $[\text{Re}(\text{en})_2\text{O}_2]^+$; RR
 72 PEN Rxn with: SO_2 , NO_2 , H_2S ; RR
 72 RAZ/GLO Rxn with: $\text{C}_6\text{H}_5\text{OH}$; RR
 72 VYA/DAV Rxn with: Pu(IV) ; RR
 73 DUD Rxn with: Br^-
 73 GOR/BAS Rxn with: CH_3COCH_3
 73 GOR/GOR Rxn with: CH_3COCH_3 ; Mec
 73 GOR/KOZ Dec, RR, Mec
 73 GOR/KOZ2 Dec, RR, Mec
 73 GOR/VOD Dec, Rxn with: RH , ROH , RCHO , R_2CO , etc.
 73 KAN/MOK Rxn with: $\text{cy-C}_5\text{H}_{10}$
 73 SHA/VYA Rxn with: Ce^{3+} ; RR, Mec
 73 SHE Rxn with: I^-
 73 TAK/OKU Rxn with: $\text{Na}_2\text{S}_2\text{O}_3$; Mec
 74 GER/KUR Rxn with: $\text{CH}_3\text{CH}_2\text{COCH}_3$; RR
 74 GIL Rxn with: mono-, and poly-Chlorophenols
 74 GOR/BAS Rxn with: Ag^+ ; RR, Mec
 74 GOR/KOZ Dec, RR, Mec
 74 KOM/GER Rxn with: $\text{CH}_3\text{CH}_2\text{COCH}_3$; RR, Mec

74 PAK/KRA Rxn with: CH_3OH , $\text{CH}_3\text{CH}_2\text{OH}$, $\text{C}_4\text{H}_9\text{OH}$, $\text{C}_8\text{H}_{17}\text{OH}$

74 SHU/NIK Rxn with: Ru(III), Ru(IV)

74 ZAM/KUN Rxn with: $\text{C}_6\text{H}_5\text{OH}$

75 CHT/AKO Rxn with: W, WS_2

75 CHU/KOK Rxn with: $\text{Pb}(\text{NO}_3)_2$

75 GOR Dec

75 KOC/MEJ Rxn with: Sulfonates and Sulfates

75 KUR/SAK Rxn with: Tryptophan

75 LYS/ATY Rxn with: $(\text{CH}_3)_2\text{NNH}_2$; Mec

75 MAT/FUJ Rxn with: CN^- ; RR

75 NIK/IVA Rxn with: Np^{4+} , Pu^{4+} ; RR, Mec

75 TAR/MAR Rxn with: α -Naphthol

75 TYU/YAK Rxn with: Sulfates, Pyridines, Pyrazoles, Nicotinic Acid; RR, Mec

75 VEB/GAE Rxn with: Acrylonitrile

76 CHU Rxn with: Sn^{2+}

76 CHU/MAS Rxn with: NCS^-

76 HOI/BAD Rxn with: Benzene, o-Xylene, Styrene, Aniline, Phenols, Alcohols; RR

76 JOY Rxn with: Arylsulfonic acids

76 KHE/DUD Rxn with: Br^-

76 PEL Dec

76 TOZ/NIS Rxn with: As(III)

77 CHE/LEB Rxn with: Ce(III), Bk(III)

77 ERI/YAT Rxn with: SO_2 ; RR, Mec

77 GAL/GAL Rxn with: 1-(p-Nitrophenyl)-2-acetylamino-1,3-propanediol

77 GIL Rxn with: Maleic acid, Fumaric acid, Glyoxylic acid, Formic acid, Oxalic acid

77 GLA/TOM Rxn with: aromatic amines, sulfanilic acid

77 GOB/CHU Rxn with: Br^- , I^- ; RR, Mec

77 GOR/SIM Rxn with: $\text{CH}_3\text{CH}_2\text{COCH}_3$; Mec

77 KOV/YAV Rxn with: Na_2S ; RR

77 KUO/LI Dec, RR

77 PRE/MAU Rxn with: $\text{C}_6\text{Cl}_5\text{OH}$, $\text{C}_6\text{H}_4\text{Cl}_2$, $\text{C}_4\text{H}_8\text{Cl}_2$, CHCl_3 , Chlorinated biphenyls

77 RIZ/AUG Rxn with: $\text{C}_6\text{H}_5\text{OH}$; RR

77 SHA/YAK Rxn with: Cumene

77 TAR/MAR Rxn with: S-ethyl-N,N-di-n-propylthiocarbamate

77 TAR/MAR2 Rxn with: Zinc dimethyldithiocarbamate and tetramethylthiuram disulfide

77 TYU Rxn with: Alkylpyridines

77 TYU/YAK Rxn with: Alkylpyridines and Alkylpyrazoles; Mec

77 YOC Rxn with: Styrene

78 AUG/RIZ Rxn with: C_6H_5OH ; RR

78 AUG/RIZ2 Rxn with: C_6H_5OH ; RR, Mec

78 CHU Rxn with: Pd^{2+} , Pt^{2+}

78 GIL Rxn with: aliphatic and aromatic acids, cresols, glyoxal

78 HOI/BAD Rxn with: NH_3 ; RR

78 ISH/DOB Rxn with: Alcohols, Phenols, Cyanohydrins, Amines, Aromatic amines, Benzothiazole

78 JOY/GIL Rxn with: Alkylbenzenesulfonic acids

78 KAS/MAT Rxn with: CN^- ; RR

78 LAR/HOR Rxn with: SO_2 ; RR, Mec

78 MOR/IKE Dec, RR

78 OEH Rxn with: Organic compounds (Review)

78 ONA Rxn with: Azo Dyes; RR, Mec

78 PRA Rxn with: Br^-

78 PRE/MAV Rxn with: Pesticides (Malathion, Baygon, Vapam, DDT)

78 SHA/KOL Rxn with: Caffeine

78 SKU Rxn with: Sodium Alkylbenzenesulfonates

78 SKU2 Rxn with: Sodium Alkyl-naphthalenesulfonates

78 SUZ/IIZ Rxn with: Polyacrylamide

78 YAK/DNE Rxn with: I^- , Mn^{2+} ; RR

78 YOC Rxn with: Styrene, Bromobenzenesulfonic acid

79 BEL Dec, RR

79 GOR/BAS Rxn with: CH_3COCH_3

79 HEA Rxn with: 2-amino-2-(hydroxymethyl)-1,3-propanediol and 2-(N-morpholino)-ethanesulfonic acid

79 LI/KUO Rxn with: C_2H_6OH ; RR, Mec

79 MAR/OBO Rxn with: Ethylenediamine

79 NAK/NAK Dec, RR

79 RAZ/OVE Rxn with: OH^- ; RR, Mec

79 STE/BEN Rxn with: Water-soluble organic substances, Nitroaniline

79 SUL/ROT Dec, RR

79 SUZ/TAU Rxn with: Water-soluble polymers; RR

79 YAK Rxn with: C_6H_5OH , Hydroquinone, Na 1-anthraquinone,
Na Benzenesulfonate, Phthalic acid, Bromobenzenesulfonic acid

80 DUG/JAU Rxn with: Glycine; RR

80 GIL Rxn with: trans-trans Muconic acid; RR, Mec

80 HUA Rxn with: 2,2',4,4',6,6'-Hexachlorobiphenyl; RR, Mec

80 JOY/GIL Rxn with: p-Toluenesulfonic acid; Mec

80 KER/TAR Rxn with: Azobenzene

80 KIR/LIT Rxn with: Ethyl mercaptan

80 LIB/BOS Rxn with: I^-

80 RUT/SZK Rxn with: HCHO

80 SUL Dec, RR

80 SUL/ROT Dec, RR

80 SUZ/MIY Rxn with: Poly(oxyethylene); RR

80 TYU Rxn with: benzimidazole, benzotriazole, Benzopyrazole; RR

80 TYU/BER Rxn with: Alkylpyridines; RR

80 TYU/YAK Rxn with: Mn^{2+} , Mn^{3+} ; RR, Mec

80 ZEE/VIS Rxn with: CN^- ; RR, Mec

81 GUR Dec; Rxn with: C_6H_5OH ; RR, Mec

81 HAR/TAK Rxn with: Br^- ; RR, Mec

81 LEG/LAN Rxn with: C_6H_5OH , Hydroquinone, Phenoxyacetic acid, Aniline

81 MAR/DAM Rxn with: SO_2

81 MAT/TAK Rxn with: NCO^- ; RR, Mec

81 MBA/MAN Rxn with: Lignin

81 PAN/CHE Rxn with: Methyl β -D-glucoopyranoside; RR

81 REU/OVE Rxn with: C_6H_5OH ; RR

81 SIE/COW Rxn with: NH_2NH_2 , CH_3NHNH_2 , $(CH_3)_2NNH_2$

81 TAK/KAT Dec, RR

81 TER/SUG Rxn with: CN^- ; RR

81 TYU Rxn with: Fe^{2+} ; RR, Mec

81 TYU/DNE Rxn with: Fe^{2+} ; RR, Mec

81 YAK Rxn with: CH_3OH , HCHO, HCOOH; Mec

Part II. References

1913

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1917

- 17 ROT/BUR Rothmund, V., and Burgstaller, A., "Die Reaktion zwischen Ozon und Wasserstoffperoxyd," Monatsh. Chem. 38, 295 (1917)

1932

- 32 KAW Kawamura, F., "Investigation of Ozone. I. The Solubility of Ozone in Water and in Dilute Sulfuric Acid," Nippon Kagaku Kaishi 53, 783 (1932); Chem. Abstr. 26:5477 (1932)

1933

- 33 SEN Sennewald, K., "Über den Zerfall des Ozons in Wasseriger Lösung," Z. Phys. Chem. Abt. A 164, 305 (1933)

1934

- 34 KAW Kawamura, F., "Investigation of Ozone. III. The Decomposition of Ozone in Aqueous Solution," Nippon Kagaku Kaishi 55, 849 (1934); Chem. Abstr. 29:27 (1935)

1935

- 35 WEI Weiss, J., "Investigations on the Radical HO_2 in Solution," Trans. Faraday Soc. 31, 668 (1935)

1937

- 37 VAS/KAS Vasil'ev, S. S., Kashtanov, L. I., and Kastorskaya, T. L., "The Kinetic Mechanism of the Chain Oxidation of Sulfur Dioxide in Solution by Ozonized Air," Zh. Fiz. Khim. 10, 330 (1937); Chem. Abstr. 32:414 (1938)

1938

- 38 BRA Bray, W. C., "The Interaction of Ozone and Hydrogen Peroxide in Aqueous Solution," J. Am. Chem. Soc. 60, 82 (1938)

1940

- 40 TAU/BRA Taube, H., and Bray, W. C., "Chain Reactions in Aqueous Solutions Containing Ozone, Hydrogen Peroxide and Acid," J. Am. Chem. Soc. 62, 3357 (1940)

1941

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1942

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1948

- 48 HIL Hill, G. R., "Kinetics, Mechanism, and Activation Energy of the Cobaltous Ion Catalyzed Decomposition of Ozone," J. Am. Chem. Soc. 70, 1306 (1948)

1949

- 49 YEA/TAU Yeatts, L. B., Jr., and Taube, H., "The Kinetics of the Reaction of Ozone and Chloride Ion in Acid Aqueous Solution," J. Am. Chem. Soc. 71, 4100 (1949)

1950

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1954

- 54 STU Stumm, W., "Der Zerfall von Ozon in Wässriger Lösung," Helv. Chim. Acta 37, 773 (1954)

1955

- 55 ABE Abel, E., "Über die Selbstzersetzung von Ozon in Wässriger Lösung," Monatsh. Chem. 86, 44 (1955)
- 55 ABE2 Abel, E., "Über die Reaktion zwischen Ozon und Wasserstoffsperoxyd in Wässriger Lösung," Monatsh. Chem. 86, 193 (1955)

1956

- 56 KIL/HER Kilpatrick, M. L., Herrick, C. C., and Kilpatrick, M., "The Decomposition of Ozone in Aqueous Solution," J. Am. Chem. Soc. 78, 1784 (1956)

1958

- 58 KLE/NAL Kleimenov, N. A., and Nalbandyan, A. B., "The Interaction of Ozone with Methyl Hydroperoxide," Dokl. Akad. Nauk SSSR 118, 125 (1958); Chem. Abstr. 52:19369d (1958)

1959

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1961

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1962

- 62 RAU/SII Raukas, M. M., Siirde, E. K., and Kyulm, S. R., "Rate of Ozone Decomposition in Different Waters," Jr. Tallinsk. Politekh. Inst. Ser. A 198, 219 (1962); Chem. Abstr. 60:2633e (1964)

1965

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1967

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1968

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1970

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1971

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