SOLUBILIZATION OF INSOLUBLE MATTER IN NATURE*

II. THE PART PLAYED BY SALTS OF ORGANIC AND INORGANIC ACIDS OCCURRING IN NATURE

by

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In part I of this series the general significance of the problem of solubilization for processes occurring in nature has been discussed and the special part played by adenosine triphosphate has been described[1]. At neutral or slightly alkaline pH and under physiological conditions of temperature, insoluble organic and inorganic compounds are solubilized by the soluble salts of a large number of inorganic and organic acids. From a biological point of view it is noteworthy that these materials also prevent precipitation of many nearly insoluble substances.

We have shown[2] that the number of these solubilizing substances—hereafter designated as "solvents"—is considerable. In this paper we shall concentrate on typical compounds which occur in nature. The number of these "solvents" could be increased enormously as analogous compounds are widely distributed. The range of materials to be solubilized—hereafter designated as "substrates"—seems unlimited.

To get an idea of the effects involved we shall report the behaviour of "solvents" selected at random: Pyrophosphates, triphosphates, metaphosphates, ribonucleates, desoxyribonucleates, α- and β-glycerophosphates, hexosemono- and di-phosphates, DL-lactates, D-glucuronates, D-galacturonates, D-gluconates, pyruvates, tartrates, malates, ascorbates, chondroitinsulfates, *iso*citrates and salts of glucosaccharic and mucic acid. Besides the alkali salts of metaphosphoric acid, salts with ethylene-diamine, ethanolamine, dimethylamine and ammonium salts were also investigated. In the case of pyrophosphate the bis-trimethylamine-disodium salt has been used as well.

To prove that more than simple cation exchange takes place experiments were devised showing the solubilization of insoluble Mg salts in Mg salts. $MgCO_3$ and $Mg_3(PO_4)_2$ were dissolved, or their precipitation prevented, by addition of Mg-glycerophosphate, Mg-gluconate, Mg-fructose-1,6-diphosphate.

It could be shown convincingly that, *e.g.*, a solution of sodium-fructose-6-phosphate after having solubilized $BaSO_4$ or $CaCO_3$ can further solubilize added $MgCO_3$, $MnCO_3$,

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$Ca_3(PO_4)_2$. This is of interest for the elucidation of the nature of the solubilization phenomena. Many of these "solvents" solubilize ammonium magnesium phosphate, calcium oxalate, calcium fluoride, uranyl phosphate, uranyl-, lanthanum- and cerous nucleates, and other similarly insoluble compounds.

The "solvents" have been applied in the form of their alkali, alkaline earth or ammonium salts, and as salts of organic bases known to occur in nature. As "substrates" we have chosen insoluble inorganic salts and organic cell constituents or metabolites. Since new examples of the participation of inorganic matter in biological processes, and the importance even of rare elements for the course of these processes are revealed daily, we have selected insoluble compounds formed by elements from all groups of the periodic table. These include: carbonates, phosphates, silicates, sulfates, borates, fluorides, fluorophosphates, chlorides, iodides, iodates, selenites, selenates, tellurates, sulfites, phosphites, arsenates, vanadates, chromates, molybdates, tungstates, sulfides, mercaptides, phosphomolybdates, phosphotungstates, oxalates, azides, cyanides, thiocyanates, cobalticyanides, ferrocyanides, ferricyanides, pectates, alginates, celluronates, nucleates.

Calcium-fructose-diphosphate (prepared from Mg fructose-1,6-diphosphate and $CaCl_2$), and the calcium salt of humic acid are solubilized by several "solvents". The same is true for many insoluble salts of Y, Zr, In, La, Ce, Pr, Nd, Th.

Pyrophosphoric acid is present in the interesting mineral pyrophosphorite[4] and is frequently considered a transformation or cleavage product of complicated organic compounds*. KORNBERG AND LINDBERG[5] have demonstrated the enzymic formation of pyrophosphate besides DPN in the system ATP-nicotinamide-ribonucleotide. A purely inorganic mother substance of pyrophosphoric acid is triphosphoric acid[6] which in turn is related to metaphosphoric acid[7].

The ability of pyrophosphates to form complexes has been known for a long time. In particular soluble double salts of insoluble pyrophosphates and soluble alkali pyrophosphates have been described. An idea of their structure is given by HALDAR[8]. It is possible that the behavior of myosin dissolved by $Na_4P_2O_7$ (AMBERSON *et al.*[9]) is due to the same phenomenon. KOHN[10] found that the solubility of insoluble ferro- and ferri-cyanides in $Na_4P_2O_7$ is due to the formation of soluble double salts of heavy metal- and sodium pyrophosphates.

Comparative and systematic investigations of the action of the "solvents" mentioned above on these "substrates" led to the data tabulated in Tables I–XXIII.

Besides the "solvents" included in the tables the solubilizing effect of salts of glucosaccharic acid, mucic acid** etc. has been investigated.

Most of the substances under consideration are constantly built up and degraded as they circulate in tissue fluids and become fixed in various organs.

To show the relationship to general and biochemical processes we should like to indicate the importance of some of the "solvents" and "substrates" for these processes. These observations include recent findings as well as older data the significance of which was not fully recognized at that time.

Among the insoluble phosphates, so-called basic salts of the type originally formulated as $Ca_3(PO_4)_2$. CaO occur far more frequently[3] than previously assumed. These substances deserve our interest since they may be considered as derivatives of the 5 basic phosphoric acid $P(OH)_5$. They include important fertilizers such as the mineral kakoxen $FePO_4 \cdot Fe(OH)_3$ and $Ca_4P_2O_9$ found in the Thomas slag of the Bessemer converter or in furnace linings (salamander). They too were brought into solution under the given conditions by some of the "solvents" tabulated.

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* Pyrophosphate is liberated from ATP in the presence of coenzyme A (F. LIPMANN, *J. Am. Chem. Soc.*, 74 (1952) 2384).

** The neutral salts of this acid formed with morpholine and piperidine are relatively soluble.

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Since the natural occurrence of metaphosphates[11] was discovered by LIEBERMANN in yeast and by HARDIN in aqueous extracts of cotton seed meal, the presence of the substance has been repeatedly reported in microorganisms and plant cells and in some cases even in animal organs[12]. SPIEGELMAN AND KAMEN[13], WIAME AND BRACHET[14] and others pointed out that different highly polymerized forms of metaphosphates occur. The molecular weight of the water soluble metaphosphate isolated from Aspergillus niger was determined as 6000–7000[15]. The existence of an enzyme, able to hydrolyze this condensed phosphate to orthophosphate increases the interest attached to metaphosphate. This enzyme was found in 1928 by KITASATO[16] in the laboratory of the senior author. The high activity and the wide distribution of metaphosphatase were described at an early date[17]. More recently it has been reported[18] that even synthetic high molecular weight polymetaphosphates of molecular weight $>1{,}000{,}000$ are depolymerized by a metaphosphatase from molds. According to ELLIS *et al.*[19] the enzyme is also present in the wool root. The effect of different cations on the ability of metaphosphate to form complexes was pointed out by VAN WAZAR AND CAMPANELLA[20]. Quaternary ammonium ions do not take part in complex formation, alkali ions form weak complexes, other metal ions give rise to strong complexes. In this connection it seems worth mentioning that even sodium can form phosphato-complexes; they are loose complexes, since the solubilizations described in this paper were easily carried out with sodium metaphosphate.

Further evidence that at least 2 species of metaphosphate occur in nature is the fact that only one form readily exchanges radioactive phosphorus with the medium. The reaction in which trimetaphosphate is formed from hexametaphosphate is irreversible[21].

As yet no triphosphoric acid has been found in nature. Kinetic studies of BELL[7] and also of VOGEL AND PODELL[21] show that hexametaphosphate is hydrolyzed to orthophosphate and trimetaphosphate. The latter can be hydrolyzed to ortho- and tri-phosphate, while triphosphate itself is hydrolyzed to ortho- and pyro-phosphate. Since we have been able to carry out the last-mentioned reaction by purely enzymic means[6] and since the wide distribution of a specific triphosphatase has been established[22], the possibility that triphosphoric acid takes part in biochemical processes can not be excluded[6]. This would be in accord with the fact that this inorganic mother substance of ATP affects reactions taking place in muscle tissues and in fermenting yeast cells[23,24].

The destruction of all amylatic activity of α-amylase[25] in the presence of $Na_5P_3O_{10}$ is due to the sequestering of the Ca^{++} ions necessary for the reaction. Similarly inhibition of peptic digestion of edestin in the presence of polyphosphate as observed by BERSIN[26] appears to be due to the complexing of activating ions.

In view of all these relationships with biological problems we made a special study of the solubilizing process of the different condensed phosphates. While various functions have been assigned to the polyphosphates[2], the role which should be ascribed to the natural storage of polyphosphates has not been elucidated. Apart from the possibility of storage for specific needs[27] there might be some connection with the processes of phosphorylation. Ordinary phosphoric anhydride is formulated as P_4O_{10} rather than P_2O_5 (PAULING). On addition of water this yields not only H_3PO_4 but also metaphosphoric acid. In ether suspension the anhydride is a useful phosphorylating agent[17], possibly due to intermediary formation of ethyl metaphosphate[28]. An addition to anhydro sugars has also been reported[29]; later phosphorylations were carried out with pyrophosphate and triphosphate[30]. Another function of polyphosphates is to split off water and bring about cyclizations[31].

$POCl_3$ which is extremely stable against water (NEUBERG, MEERWEIN) and reacts as a mixed anhydride of $PO(OH)_3$ and HCl is also the simplest reagent for the production of acid esters of pyrophosphoric acid in aqueous solution[17,32].

As a final example of the manifold transformations of phosphoric acids, the transformations of orthophosphates and phosphites under neutron bombardment might be mentioned. In the course of these reactions salts of hypophosphoric acid, H_3PO_2, are formed[33]; we have therefore included hypophosphites and phosphites in our investigations. The latter are of interest since BABA[34] has found an enzymically cleavable monoallylphosphite in nature.

Besides the "bioelements" many other elements take part to a greater or lesser degree in biological processes. Their physiological behavior is being investigated to an increasing extent, partly in connection with isotope studies. The number of relevant publications is enormous and only a scattered few will be referred to:

Problems of the migration and precipitation of Ca carbonate and phosphate in organisms are treated extensively[35] in connection with histoplasmosis and pulmonary calcification (CHRISTIE) on the one hand, shell formation in molluscs (BEVELANDER) on the other.

Calcium and fluorine show a definite tendency to form combinations with phosphates. The oldest example is the wide distribution of apatite $Ca_5F(PO_4)_3$. In the inhibition of enolase WARBURG AND CHRISTIAN[36] demonstrated the formation of an organic magnesium fluorophosphate complex, thus explaining for the first time the cause of fluoride inhibition of enzymes. A similar combination is assumed in the case of phosphoglucomutase[37] while lecithin is believed to take part in complex formation with calcium and magnesium through its phosphate residue[38]. Many instances of analogous behavior are known[1,2,3]. Permanent or temporary formation of complexes of the type which may

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be involved in the solubilization effects described in this paper has also been observed in the binding of iron by lycomarasmin[39] or the chelating of cobalt by histidine[40]. The removal of inhibiting ions by precipitation or sequestration has also been described[41]. Coordinate complexes of antimonyl compounds[42], translocation of iron in pineapple[43], combinations of plasma globulin with metals[44] and complex formation with inorganic acids in connection with phosphatase activity[45] belong to this group. An account of the essential constituents of sea water for growth of marine diatoms[46] and a review on complexes in physiological chemistry[47] furnish many remarkable details.

Some lesser known facts about trace elements may be worth mentioning: Zn is a universal antagonist of snake and bee poisons[48]. After RAULIN (1869) had shown the need for Zn to satisfy the mineral nutritional requirements of certain fungi and a special chemical role had been assigned to Zn in the transformation of intermediaries of carbohydrate metabolism[48], gallium which frequently accompanies zinc in trace amounts was found to be a necessary oligometal for the development of Aspergillus niger[49]. The presence of Cr in plants[50] seems worthy of attention. WIELAND AND SONDERHOFF[51] found that oxidative conversion of acetic acid to succinic and citric acid by yeast was possible in the presence of Ba^{++} salts. According to CORI[52] the enzymic formation of glycogen from hexosephosphates is catalyzed by Ba^{++}. In Brazil nuts Ba is stored to more than 1% of the dry weight[53].

Lead, which can accumulate in plants[54], appears to play a part in a special effect of hyaluronidase; in its presence the erythrocite sedimentation due to hyaluronidase is increased[55]. Enzymic decarboxylations of oxaloacetic acid are activated by a considerable number of bivalent cations including Pb, Ba, Cd[56]. HENZE's discovery[57] that the blood cells of ascidians contain a chromogen which on ashing yields 10% V_2O_3 is one of the remarkable observations in the history of biochemistry. V is present in relatively large amounts[58] in plants and animals including human teeth[59] as well as in petroleum and other fossil materials[60]. In these remnants of the tertiary geological period V is bound to porphyrins. The V complexes were formed through transmetallization from substances resembling chlorophyll and hemin[61].

After early investigations of SOEHNGEN (1913) have stressed the importance attached to the changes in nature from soluble to insoluble Mn compounds and vice versa more recent findings[62] show the existence of a Mn cycle in the soil. Due to the simultaneous action of inorganic and organic soil constituents Mn goes through various oxidation stages in this cycle. EDLBACHER AND BAUR[63] report a Mn-proteid in arginase. In this complex Mn can be replaced by Cd or V^{++}. According to HOFMANN[64] Mn is of particular importance for the development of fungi and plants.

The solubilization of insoluble matter must play a significant part in processes occurring in the soil. The number of "substrates" would be unlimited, the number of "solvents" considerable. These "solvents" get into the soil with dead animal or plant residues, but in part they are also formed directly by the living organisms present in the soil.

This is true, *e.g.*, for nucleic acids and nucleotides. As early as 1893 PETIT[65] found nucleic acids in humus. KOCH AND OELSNER confirmed this[65] and recognized that the nucleic acids formed are conserved intact in the soil for many months and are only slowly decomposed by the normal microbial flora. SCHREINER[66] arrives at a similar conclusion and other authors too[67] advanced evidence for the presence of nucleic acids and nucleotides in the soil. Other relatively stable substances present in the soil are the phytates. Their occurrence has been reported by WRENSHALL, DYER AND SMITH[68] as well as by YOSHIDA[69]. Besides the salts of inositol hexaphosphate (phytin), inositol monophosphates seem to be present[70]. In plants phytin occurs as a Ca–Mg salt, but also as pure Ca-phytate[71].

The "solvents" investigated also include uronic acid derivatives which in various forms are widely distributed in nature. The special importance of conjugated glucuronic acids for the problem of solubilization has recently been stressed by us[72]. In addition we studied salts of free glucuronic and galacturonic acids, of polygalacturonic, alginic and polyanhydroglucuronic (celluronic) acids. Different polyuronides, mixed polymers of oligosaccharide and uronic acid units, play an important role as residues of higher and lower plants, fungal and bacterial polysaccharides in the carbohydrate metabolism of the soil[73]. Condensed uronic acids occur in iles mannan[74], in cereal straws[75] and in cereal products[76]. We have investigated salts of D-mannuronic acid and its carboxylic acid group containing polymerized anhydride known as alginic acid, both as "solvents" and as "substrates" in our solubilization studies.

Amongst the "solvents" the ester sulfates of high molecular weight deserve special mention. SYLVÉN's investigations[77] show their occurrence and their role in processes taking place during the development of the stromal matrix, fibroblasts, mast cells, mesenchymal tumors and new formations of tissues and in local detoxication reactions in granulation tissue. The protective action of chondroitin sulfate preventing precipitation of $BaSO_4$ has been observed at an earlier date[78].

"Substrates" investigated include protein-metaphosphates. While metaphosphoric acid has been

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used as a protein precipitant for a long time, well-defined crystallized reaction products were first described by PERLMANN[79]. A new biological function has been assigned by OHLMEYER[80] to the insoluble compounds formed between proteins and nucleic acids, the solubilization of which we investigated previously[1,2] and in the present study.

Enzymes bound to cell nuclei show only a fraction of their activities. They become fully activated when a protein is added to combine with the nucleic acid of the cell nucleus thus liberating the enzyme by protein exchange. These facts are in accord with an older finding of WARBURG AND CHRISTIAN[81] who liberated the oxidative fermentation enzyme precipitated with nucleic acid by an exchange reaction with protamine. GEBERS AND DEUTICKE[82] reported a special solubilizing ability of salts of nucleotides of the adenylic acid system for muscle proteins. The many examples of the ability of nucleates and related substances to form a large variety of complexes[1,2] appear to be related to a number of enzyme interactions[83].

We have previously reported the solubilizing ability of the most diverse groups of organic acid salts[2]. In connection with these "solvents" some additional remarks seem in order: The number of acids known to be intermediaries or end products of metabolism is very large. FOSTER AND CARSON[84], BERNHAUER[85], ENY[86] and THIEMAN AND BONNER[87] give details on the formation and occurrence of acids important for animal and plant organisms. Evidence for complex formation of malonates, succinates, carbonates and pyruvates, was advanced by RILEY *et al.*[88]. Organic acid salts of this type have a function in the uptake of insoluble material from the soil. They are eliminated by plant roots together with nucleotides according to LUNDEGÄRDH AND STENDLID[89]. Relatively simple phosphorylated substances belong to the same group. Sugar phosphates have long been recognized as products of microorganisms and animal cells. BURKHARD AND NEUBERG[90] isolated phosphoric acid esters of various sugars from beet leaves. BARRENSCHEEN AND PANY[91] have shown that fructose monophosphate results from assimilation. It is well known that more recently phosphoglycerate has been recognized as the primary product formed in the assimilation of green plants. Its homologue, phospho-D-arabonate[92] and the glycerophosphates widely distributed in nature should also be mentioned. The α- and β-forms of the latter compound show the same "solvent" behavior; it is possible that their buffer capacity[93] which is used in certain cases is connected with solubilization effects.

A short summary of a few other findings connected with the problem may be appended[94]. Pyro- and meta-phosphates prevent blood clotting[a]; ordinary orthophosphate can act as a phosphorylating agent *in vitro*[b]; metaphosphate may possibly be originally bound in cells[c]; phosphosilicic acid ester is said to occur in the mannogalactan of trigonella foenum graecum[d]; silicic acid itself is present in animal organs in the form of an alcohol-ether soluble ester[e]. Uranium is deposited in the animal skeleton[f] and accumulated by cyanophycees[g]. Uranyl salts form complexes with glycerophosphates[h] as with many simple polyhydroxycompounds. Molybdates form complexes with phosphoric acid esters[i] as well as with H_3PO_4 and exert a catalytic effect on the hydrolysis of organic phosphate bonds[k]. La is present in yeast[l]; Nd precipitates proteins from very dilute solutions[m]. Thorium is an activator for polygalacturonidase[n]. Ca, the complexes of which have been recently investigated[o, p], has been found to have definite functions in the activation of proteolytic and other enzymes[q, r, s]. The relation of Be to problems of general toxicity and specific enzyme inhibition has been studied[t] and the same is true for the acids of selenium[u].

Amongst the "solvents" investigated we have included *iso*citrates since they are regular products of metabolism. Besides the naturally occurring optically active acid* we have used the racemic *iso*citric acid made according to the directions of PUCHER AND VICKERY[v]. Salts of D-glucosaccharic acid were studied since this acid has occasionally been found in nature and may act as an intermediary in the formation of citric acid by aspergillus niger[w]. Furthermore, the acid deserves attention as specific inhibitor of β-glucuronidase[x]. A Ba-metabolism has been described in the larvae of Drosophila repleta[y]. Finally reference might be made to the relationships between the problems of the present investigation and the phenomena of hydrotropy[z]. Recently FLIEG[z] referred to this point; he called attention to the fact that the solubility of calciumphosphate is increased in the presence of surface-active substances, such as saponins, soaps, alkaline humates and sodium choleinate.

The relevant facts selected and referred to give some idea of the variety of aspects connected with the problems under consideration and the many relationships resulting therefrom.

The solubilization processes are essential. This is why we believed that the study of this phenomenon should be extended and placed on a wider basis, the more so as many of the results are unexpected. The data collected are too voluminous to be reported completely, but typical examples selected from the various groups and tabulated below should indicate the range and allow comparisons of the substances studied.

* We are indebted to Prof. H. B. VICKERY for a sample of this acid.

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EXPERIMENTAL

The experiments indicated in the tables were carried out according to the schemes and description given in Part I of this series[1].

The following abbreviations are used in the tables (pp. 546–565)

ppt. = precipitate	cl. = clear	b. = boiling	sh. = shaking
inh. = inhibition	r.cl. = remains clear	w. = warming	slig. = slightly
t. = turbid	alm. = almost	st. = standing	C. = Control
sol. = solution	o = no solution		

MP	= Sodium metaphosphate	Na Pyr.	= Sodium pyruvate
PP	= Potassium pyrophosphate	Na Lact.	= Sodium lactate
TP	= Sodium triphosphate	NH_4 Lact.	= Ammonium lactate
EMP	= Monoethanolamine metaphosphate	NH_4 Ch.S.	= Ammonium chondroitin sulfate
NaG	= Sodium glycerophosphate	Na Mal.	= Sodium malate
RN	= Sodium ribonucleate	MgFP	= Magnesium fructose-diphosphate
Na Cel.	= Sodium celluronate	Mg G	= Magnesium glycerophosphate
Na Gal.	= Sodium galacturonate	Na Glyc.	= Sodium glycolate
Na Asc.	= Sodium ascorbinate	CMMS	= Sodium carboxymethylmercapto-succinate
Na Gluc.	= Sodium glucuronate		
Na Gl.	= Sodium gluconate	DRN	= Sodium desoxyribonucleate
Mg Gl.	= Magnesium gluconate	K Tart.	= Potassium tartrate

The inorganic "substrates" mentioned in the tables are formulated as normal compounds regardless of occasional deviation in composition.

General remarks

A cursory glance at the experimental material presented shows a wide range of naturally occurring substances with solubilizing abilities. These "solvents" can act on an enormous number of inorganic and organic compounds under physiological conditions of temperature and hydrogen ion concentration. A significant concomitant of solubilization is more or less complete deionization of the "substrate". Important elements such as, *e.g.*, the biometals are thus protected from precipitation and removal from the sphere of biological activity. The binding of pharmacologically effective substances to "solvents" may produce altered conditions. For processes taking place in animal or plant organisms it is noteworthy that the "solvent" besides bringing the "substrate" into solution enables it to migrate through the organism. The carrier function may be stopped by enzymic degradation of the "solvents" and the previously dissolved material be made available for specific reactions at new sites. The "solvents" investigated are naturally occurring substances and known substrates for specific enzymes. We must assume a constant regeneration of the enzymes but also of the "solvents" which are among the regularly circulating products of cellular metabolism. A mechanism is thus envisaged which by a continuous chain of events serves biological tasks. We have shown that such mechanisms do exist*. It might be added that enzymic degradation products of difficultly soluble compounds, often readily soluble in the form of their neutral salts, may become good "solvents" for the originally insoluble "substrate". Evidence indicates that nature competes with itself to provide more and better solubilizing agents.

We are indebted to Dr MARIANNE KREIDL for helpful assistance.

* These examples will be given in detail in a later publication. For a preliminary report see *Federation Proc.*, 11 (1952) 253.

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TABLE I

MAGNESIUM AND CALCIUM SALTS

Substrate.

Solvent	$CaCO_3$*	$Ca_3(PO_4)_2$**	$MgCO_3$***	$Mg_3(PO_4)_2$†	$MgNH_4PO_4$††
M MP	1 ml sol.	1 ml sol.	1 ml sol.	0.5 ml inh.	
M PP	0.5 ml sol.	0.5 ml sol.			
M/2 TP	1 ml sol.	1 ml sol.			
M EMP	1 ml sol.	1 ml sol.			
M NaG.	1 ml sol.	2 ml inh. r.cl.			
5% RN	1 ml sol.	2 ml sol.			
10% Na Cel.	0.75 ml sol.	2 ml sol. pH 7, at higher pH t. 1 ml inh.			1 ml sol. alm.cl. 1 ml inh. pH 8, if $MgCl_2$ added first, before other ingredients t.
M Na Gal.	0.5 ml sol.	0.5 ml sol. pH 7, at pH 8 t.	0.5 ml sol.		
M Na Asc.	1 ml sol.	2 ml inh.	1.5 ml sol. r.cl. on w.		2 ml inh.
M Na Gluc.	0.5 ml sol.	2 ml inh.	1 ml sol.		1.5 ml inh. r.cl. on w.
M Na Gl.	1 ml sol. pH 8	3 ml inh. pH 9	0.2 ml sol. pH 9	1.0 ml inh. pH 9, r.cl.	
M Na Pyr.	0.5 ml sol. up to pH 9	1 ml sol. on st. pH 7, on w. t.	0.5 ml sol. pH 7, r.cl. up to pH 9	0.5 ml sol. on st. pH 7	0.5 ml inh. 1 ml sol. r.cl. (1 h observed)
M NH_4-Lac.	0.1 ml sol. at pH 11 t.	1 ml sol. pH 7–8, on w. t.	0.1 ml sol. pH 8, cl. up to pH 9	0.5 ml inh. r.cl. up to pH 8, on st. t.	
M Na-Lac.	1.5 ml sol. pH 8	2.5 ml alm. sol. pH 7.5, at higher pH t.	1 ml sol. pH 8	1 ml sol. pH 8	
10% NH_4 Ch.S.	2 ml sol. r.cl. on warming	2 ml inh. r.cl. on w.			2 ml inh.
M/4 Mg Gl.			1.5 ml sol. on st. after 5′ 1.5 ml inh.	1.5 ml inh. r.cl. on w.	1 ml inh. after 5′ t.
M Na Mal.					2 ml sol. w.

* C: 2 ml H_2O: o.

** C: 3 ml H_2O ppt.

*** ppt. forms on w., C: 1 ml H_2O ppt. remains. C: 5 ml H_2O, inhibition on addition of NH_4OH cryst. ppt.

† ppt. on w., C: 3 ml cold H_2O alm. cl., ppt. on w.

†† C: 2 ml H_2O ppt.

Experiments were also carried out with: *M* Na-glycolate, 1.5 *M* K-tartrate, *M* Na-carboxymethylmercaptosuccinate††† (resemblance with citric acid) and 6% Na-desoxyribonucleate. The results were analogous.

††† Formula:

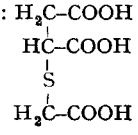


TABLE II

COPPER, ZINC, CADMIUM AND BARIUM SALTS

Solvent	Substrate							
	$CuCO_3$*	$Cu_3(PO_4)_2$**	$CdCO_3$***	$Cd_3(PO_4)_2$†	$ZnCO_3$	$Zn_3(PO_4)_2$	$BaSO_4$	$BaSO_4$ ($M/100$)††
M MP	0.5 ml sol. blue	0.3 ml sol. pale blue	1 ml sol. w. on st. 3′	0.7 ml sol.	0.5 ml sol.	0.3 ml sol.	0.3 ml inh.	
M PP	0.25 ml sol.	0.3 ml sol.	1 ml sol. w.	0.3 ml sol.	0.5 ml sol.	0.3 ml sol.	1.6 ml inh.	
M/2 TP	0.3 ml sol. blue	0.2 ml sol. blue	1 ml sol. w.	0.3 ml sol.	0.5 ml sol.	0.3 ml sol.		
M EMP	0.5 ml sol. blue	0.2 ml sol. blue	0.5 ml sol. w.	0.3 ml sol.	0.5 ml sol.	0.3 ml sol.		
M/2 MFP	1 ml sol.	1.4 ml inh.	2 ml inh.	1.4 ml inh.	1.5 ml sol.	1.4 ml inh.		
M MgG	2.5 ml sol. on st. 5′	1.4 ml inh.	2 ml inh.	1.4 ml inh.	2 ml sol.	1.4 ml inh.		
5% RN	1.5 ml sol.	1 ml sol.	2 ml inh.	1.4 ml inh.	1 ml sol.	1.4 ml inh.		
10% Na Cel.	1 ml sol. pH 6 r.cl. up to 7.5 after 15′ reduct.	1 ml sol. pH 6 r.cl. up to 7.5 after ½ h reduct.			2 ml sol. on st. 15′	2 ml inh. pH 6 r.cl. up to 8.5		0.7 ml inh. r.cl. ½ h
M Na Gal.		0.5 ml sol. on w. reduct. 0.5 ml inh.				0.5 ml inh. after 5′ t.		with some NH_4OH 0.5 ml inh. r.cl. 2 weeks
M Na Asc.					1 ml sol.			0.4 ml inh. r.cl. 1 h
M Na Gluc.					0	2 ml inh. alm.cl.		0.4 ml inh.
M Na Gl.					2 ml sol.	1.5 ml inh.		on st. t.
M Na Pyr.	0.5 ml sol.	0.5 ml sol. pH 6 r.cl. to 8 on w. ppt.			0.5 ml sol. pH 6, r.cl. to pH 7.5	0	2 ml inh. r.cl. 2 h	0.4 ml inh. r.cl. 48 h
M NH_4-Lac.					1 ml sol. pH 6, r.cl. to pH 10	0		
M Na-Lac.					3 ml sol.	0		3 ml inh.
M NH_4 Ch.S.		1 ml inh.			2 ml sol.	2 ml inh.		1 ml inh. after 2′ t.
M/4 Mg.Gl.	2 ml inh.	1.5 ml inh.						
M Na Mal.	0.5 ml sol.	0.5 ml sol. pH 6 r.cl. up to 7.5			0.5 ml sol.	2 ml inh.		
M Na Glyc.	0.5 ml sol.	1 ml sol.			1 ml sol.	2 ml alm.cl. sol.	4 ml inh. r.cl. 2 h	0.5 ml inh. r.cl. 1 week
M CMMS								0.4 ml inh. 1 h observed. cl.
6% DRN								0.4 ml inh. r.cl. 24 h
1.5 *M* K Tart.	0.75 ml sol.	0.75 ml sol.						

Remarks to Table II

* C: 2 ml H_2O t.
** C: 3 ml H_2O flakes. The inh. with NH_4 Ch.S. is convincing, as direct sol. does not work, therefore the NH_4 salt does not dissolve by complex formation.
*** C: 2 ml H_2O t. 2 ml Na acetate flakes.
† C: as above.
†† On addition of 1 ml Glacial Acetic acid t. on w. The ppt. of $BaSO_4$ is redissolved in 5 ml of *M* MP resp. *M* PP. C: inh. with 4 ml H_2O ppt. In the experiment with Na Pyr. the order of addition is important: first $BaCl_2$, then pyruvate, then Na_2SO_4; otherwise ppt. forms on adding Na_2SO_4 to the pyruvate solution.

TABLE III

ALUMINUM, TIN, LEAD, BISMUTH AND CHROMIUM COMPOUNDS

Solubilizing agents

Substrate	*M MP*	*M PP*	*M/2 TP*	*M EMP*	*M/2 MFP*	*M NaG*	*M MgG*	*5% RN*	*Remarks*
$Al(OH)_3$	0.1 ml sol. on st. 5′	0.1 ml sol. w.	0.1 ml sol. w.	0.1 ml sol. w.	0.7 ml inh. cl. on st. 5′		0.2 ml inh.	0.2 ml inh.	C. 1 ml H_2O gelatinous
$AlPO_4$	0.5 ml sol. w.	0.5 ml sol. w.	0.2 ml sol. w.	0.5 ml sol. w.	0.7 ml inh.		0.7 ml inh.	0.7 ml inh.	C. 2 ml H_2O ppt.
$SnO.xH_2O$	1 ml sol.	2 ml sol.	2 ml sol.	2 ml sol.		3 ml inh.		3 ml inh.	C. 3 ml H_2O t.
$Sn_3(PO_4)_2$	1.4 ml sol. w.	1.4 ml sol. w.	1.4 ml sol. w.	1.4 ml sol. w.		2 ml inh.		2 ml inh.	C. 2 ml H_2O t.
$PbCO_3$	2 ml sol. on st. 5′	0.7 ml sol.	2 ml sol.	1.5 ml sol.				2 ml inh.	
$Pb_3(PO_4)_2$	2 ml inh.	2 ml sol. w.	2 ml inh.	2 ml inh.				2 ml inh.	
$Pb(CN)_2$	1 ml sol.	0.5 ml sol.	1 ml sol.	0.5 ml sol.	o	o		2 ml sol. on st. t.	
$PbSO_4$	2 ml sol.	1.5 ml sol. w.	2 ml sol.	1 ml sol. on st. 3′				2 ml inh.	
$PbCrO_4$	3 ml sol. w.	1 ml sol.	2 ml sol.	2 ml sol.				2 ml inh.	
$Bi_2O_2CO_3$ *M*/100	o	5 ml sol. w.	o	o			o	o	$Bi(NO_3)_3$ with TP ppt.
$BiPO_4$ *M*/100	2 ml sol. t.	2 ml sol.	1.5 ml sol. t.	1.5 ml sol. t.	3.5 ml sol.		2 ml sol.	4 ml sol. t.	C. 2 ml 2 *M* Na-acetate o
BiI_3 *M*/100	2 ml sol. (colorless)	1 ml sol. (colorless)	1 ml sol. (pale orange)	2 ml sol. (pale orange)			2 ml sol. w.	5 ml inh.	C. 5 ml H_2O ppt. on st. 2′
$Cr(OH)_3$	o	o	4 ml inh.	4 ml sol. w.			4 ml inh.	3 ml inh. on st. 5′ t.	MFP, MgG, RN all remain clear
$CrPO_4$	3 ml inh. (greenish)	o	o	2 ml sol. (greenish)	3 ml sol. on st. 5′		3 ml sol. w.	2 ml sol. w. (greenish)	on acidifying with CH_3COOH

Experiments with Al and Pb salts were also carried out using *M* NH_4- and *M* Na-lactate, *M* Na-malate, *M* Na-glycolate, 1.5 *M* K-tartrate as solvents; results were analogous.

TABLE IV

BERYLLIUM, YTTRIUM, PRASEODYMIUM, NEODYMIUM, TITANIUM, ZIRCONIUM, CEROUS, CERIC, THORIUM SALTS

Solubilizing agents

Substrate	*M MP*	*M PP*	*M/2 TP*	*M EMP*	*M NaG*	*5% RN*	*Remarks*
$Be(OH)_2$	2 ml sol.	2 ml t.	2 ml sol.	1 ml t.	2 ml sol.	2 ml inh. pH 6 r.cl. to pH 8	All clearer on st. a few min.
$BeCO_3$	2 ml sol.	2 ml sol.	1 ml sol.	1 ml sol.	2 ml sol.	1.5 ml sol.	
$Be_3(PO_4)_2$	1 ml inh.	0.5 ml sol.	1 ml inh.	1 ml inh.	o	1 ml inh. pH 6 r.cl. to pH 9	
$Y(OH)_3$	1 ml sol.	1 ml sol.	0.5 ml sol. on st. 5′	0.3 ml sol.	1.5 ml inh.	1 ml inh.	
YPO_4	2 ml sol. w. on st. 5′	2 ml sol. w.	2 ml sol. w.	2 ml sol. w. on st. 5′	3 ml inh.	2 ml sol. w. on st. 5′	
$Pr_2(CO_3)_3$	1 ml sol.	0.5 ml sol.	1 ml sol.	1.5 ml sol.	2.5 ml sol.	3 ml inh.	
$PrPO_4$	3 ml inh.	3 ml inh.	3 ml inh.	3 ml inh.	3 ml inh. cl. on st. 5′	3 ml inh. pH 6 r.cl. to pH 9	
$Nd_2(CO_3)_3$	1 ml sol.	0.5 ml sol.	0.5 ml sol.	1 ml sol. w. incomplete	o	2 ml inh. pH 6.5 r.cl. to pH 9	
$NdPO_4$	3 ml inh.	3 ml inh.	3 ml inh.	3 ml inh.	o	3 ml inh.	
$Ti(OH)_4$	3 ml inh.	3 ml inh.	3 ml inh.	3 ml inh.	3 ml inh.	3 ml inh.	
$TiO_2 \cdot P_2O_5$	2 ml inh.	2 ml inh.	2 ml inh.	2 ml inh.	2 ml inh.	3 ml inh.	
$Zr(OH)_4$	3 ml inh. t.	2 ml inh.	3 ml inh.	3 ml inh.	5 ml inh.	3 ml inh. t.	The $Zr(NO_3)_4$ solution used was slightly turbid.
$Zr_3(PO_4)_4$	2 ml inh. t.	1.4 ml inh.	2 ml inh. t.	2 ml inh. t.	4 ml inh. t.	2 ml inh. t.	
$Ce(OH)_3$	4 ml sol. w.t.	2 ml sol.	2 ml sol. t.	3 ml sol. w.	o	2 ml sol.	
$CePO_4$	3 ml inh.	4 ml sol. w.	3 ml inh.	3 ml inh.	3 ml inh. t.	3 ml inh.	
$Ce_2(CO_3)_3$	1 ml sol.	0.5 ml sol.	0.5 ml sol.	1.5 ml sol.	3 ml inh. t.	2 ml sol. t.	
$Ce(OH)_4$	3 ml inh.	3 ml inh.	3 ml inh.	3 ml inh.	3 ml inh. t.	3 ml inh.	Ceric-nucleate dissolves in excess of RN, MP, PP, TP, NaG, EMP.
$Th(OH)_4$	3 ml sol. t.	3 ml sol. w.	3 ml sol. w.	3 ml sol. w.	5 ml inh.	5 ml inh. t.	
$Th_3(PO_4)_4$	2 ml sol. t.	2 ml sol. w.	2 ml sol. w.	2 ml sol. w.	o	4 ml inh. t.	

TABLE V

INDIUM, LANTHANUM AND THALLOUS COMPOUNDS

Solubilizing agents

Substrate	*M MP*	*M PP*	*M/2 TP*	*M EMP*	*M NaG*	*5% RN*	*Remarks*
$In(OH)_3$	3 ml alm. sol.	1.5 ml sol. w.	3 ml sol. w.	3 ml sol. w.	3 ml inh.	3 ml inh. at first slig. pp. cl. on st. 5	
$In_2(CO_3)_3$	3 ml inh.	3 ml inh.	3 ml inh.	3 ml inh. t. on warming cl.	3 ml inh.	3 ml inh. t. on st. cl.	
$InPO_4$	3 ml inh.	3 ml inh. t. on st. alm. cl.	3 ml inh.	3 ml inh.	3 ml inh. on st. slig. t.	3 ml inh. t. on st. cl.	
In_2S_3	3 ml inh. on st. t.	3 ml inh. alm. cl.	3 ml inh.	3 ml inh. slig. t. on w. alm. cl.	3 ml inh. after 3′ t.	3 ml inh. on st. cl.	It is of physiological interest that In_2S_3 remains clear in RN at a pH up to 8.
$La(OH)_3$	1 ml sol. w. on st. 5′	1 ml sol. w.	1 ml sol.	1 ml sol.	3 ml inh. t.	3 ml inh. t. on st. cl.	
$La_2(CO_3)_3$	1 ml sol.	0.5 ml sol.	1 ml sol.	1 ml sol.	3 ml inh. t.	3 ml inh.	
$LaPO_4$	3 ml inh.	3 ml inh.	3 ml inh.	3 ml inh.	3 ml inh. t.	3 ml inh.	
TlI ($M/100$)	1 ml sol.	0.25 ml sol.	0.5 ml sol.	0.5 ml sol.	2 ml sol.	1 ml sol.	sol. w. also with 2 ml each of: $M/10$ Na_2HPO_4, Na_2CO_3, NH_4Cl, $Na(CH_3COO)$, NaCl, $CaCl_2$, $MgCl_2$.
Tl_2S ($M/100$)	3 ml inh. on st. t. (discolored)	3 ml inh. darkens after 5′	3 ml inh. colorless after 1 hour slig. t.	3 ml inh. colorless after 1 hour slig. t.	3 ml inh. after 10′ flocks	3 ml inh. cl. 1 hour (dark yellow)	in all cases one drop of ammono sol. (equimolar amounts of NH_4OH and NH_4Cl) added. C. ppt. with 3 ml H_2O.

TABLE VI

SILVER, MERCUROUS AND MERCURIC SALTS

Solubilizing agents

Substrate	*M MP*	*M PP*	*M/2 TP*	*M EMP*	*M/2 MgFP*	*M MgG*	*5% RN*	*Remarks*
AgCN	o	3 ml sol. w.	o	2 ml sol. w.	o	o	2 ml sol. on st. 5′	
Ag_3PO_4	o	1.3 ml sol. w.	o	0.5 ml sol. w.	o	o	0.7 ml sol.	
Ag_2CO_3	1.5 ml inh.	1.5 ml inh.	1.5 ml inh.	2.5 ml sol. w.	o	o	1 ml sol. w.	C. 1.5 ml H_2O ppt. 1 ml Na-acetate ppt.
AgCl	o	3 ml inh.	o	2 ml sol. w.	3 ml inh.	o	2 ml sol. w.	
AgI	o		o	o			3 ml inh.	C. 3 ml H_2O ppt.
Ag_2CrO_4	2.5 ml inh.	1.5 ml sol.	o	1.5 ml inh.	o	o	2 ml sol. w.	C. 2 ml H_2O ppt.
AgCNS	o	2 ml sol. w.	o	o	3 ml inh.	o	2 ml inh.	
HgCl	5 ml inh.	2 ml sol.	5 ml inh.	5 ml inh.	o	o	3 ml inh. after 5′ reduction	
Hg_3PO_4	1 ml sol. w.	0.4 ml sol.	0.7 ml sol.	0.7 ml sol.	o	o	0.7 ml sol.	0.1 ml *M*/10 Na-acetate is added when forming ppt.
$HgCO_3 \cdot 2HgO$	1 ml sol.	1 ml sol.	1 ml sol.	0.5 ml sol.	2 ml sol.	o	2 ml sol. after 5′ t.	
HgO	2 ml inh.	o	2 ml inh.	2 ml sol. w.	2 ml inh.	o	2 ml sol.	
$Hg_3(PO_4)_2$	1 ml sol.	0.5 ml sol. w.	1 ml sol.	0.5 ml sol.	1 ml inh.	2 ml sol. w.	0.75 ml sol.	
HgI_2	5 ml sol. w. (colorless)	2 ml sol. w. (alm. colorless)	5 ml sol. w. (colorless)	4 ml sol. w. (colorless)		2 ml inh. t. on w. cl. on st. t.	3 ml sol. w. (colorless)	

TABLE

URANYL, MANGANESE, FERROUS,

Sub-

Solvent	UO_2HPO_4*	UO_2S	$MnCO_3$**	$Mn_3(PO_4)_2$	$FeCO_3$***	$Fe_3(PO_4)_2$†
M MP	3 ml inh.	2 ml sol. w.			0.3 ml sol. on w. t. (green-yel.)	0.4 ml sol. (colorless)
M PP	3 ml sol. w.	3 ml sol. w.			0.5 ml sol. (colorless)	0.2 ml sol. (colorless)
M/2 TP	3 ml inh.	2 ml sol. w.			0.5 ml sol. (alm. colorless)	0.2 ml sol. (colorless)
M EMP	0	1 ml sol. w.			0.3 ml sol. (alm. colorless)	0.2 ml sol. (colorless)
M/2 MFP		2 ml inh.			1 ml sol. (greenish)	0.9 ml sol.
M NaG						
M MgG	2 ml inh.	2 ml inh.			2 ml sol. (green)	1 ml inh.
5% RN	3 ml inh. t. cl. on sh.	2 ml inh. (green-black)			2 ml sol. (greenish)	0.7 ml sol. (green)
M Na Cel.					1 ml sol.	
M Na Gal.				0		
M Na Asc.				0	0	1 ml inh. on st. or w. t.
M Na Gluc.	2 ml inh. pH 6 at higher pH t.			2 ml inh.		0.6 ml sol. on st. 2′
M Na Gl.				1 ml inh.	0.4 ml sol. on st. 2′ (greenish)	
M Na Pyr.			0.5 ml sol. pH 7, at pH 8 t.	0	0.5 ml sol.	1 ml sol.
M NH_4-Lact.			0.4 ml sol.		0.4 ml sol. on st. t. (greenish)	0.6 ml sol. after 1 h t.
M Na-Lact.			1.5 ml sol.	0	1 ml sol. pH > 8 t.	1.6 ml sol. on st. 5′
M NH_4 Ch.S.				2 ml inh.	2 ml sol.	2 ml inh.
M/4 Mg Gl.					2 ml inh. (colorless)	2 ml inh. (alm. colorless)
M Na Mal.			0.5 ml sol.	2 ml inh.	0.5 ml sol. (greenish)	

* Sol. cl. after standing some min.
** C. 2 ml H_2O or *M*/10 Na-acetate t.
*** C. as above.
† C. as above.
†† C. all solutions combined no ppt.
††† The inh. experiments with Co and Ni are convincing as Ch.S. does not dissolve, that means that the NH_4 part of the salt does not dissolve by complex formation.

Experiments were also carried out with *M* Na-glycolate, 1.5 *M* K-tartrate and *M* Na-carboxymethylmercaptosuccinate. The results were analogous.

VII

FERRIC, COBALT AND NICKEL SALTS

strate

$Fe(OH)_3$††	$FePO_4$	$CoCO_3$	$Co_3(PO_4)_2$	$NiCO_3$†††	$Ni_3(PO_4)_2$
1 ml sol. w. (yellow)	0.7 ml sol. w.	0.2 ml sol.	0.2 ml sol. (viol. pink)	1.5 ml sol. on st. 5′	0.4 ml sol.
1 ml sol. w. (yellow)	0.7 ml sol.	0.3 ml sol.	0.2 ml sol. (violet)	1 ml sol.	0.3 ml sol.
1.5 ml sol. w. (colorless)	0.7 ml sol. w.	0.2 ml sol.	0.2 ml sol. (viol. pink)	1 ml sol. on st. 3′	0.4 ml sol.
1 ml sol. w. (colorless)	0.7 ml sol. w.	0.3 ml sol. w.	0.2 ml sol. (violet)	1 ml sol. on st. 3′	0.4 ml sol.
2 ml inh. cl. on st. 5′	1.7 ml sol.	1 ml inh.	0.7 ml inh.	2 ml sol.	1.5 ml inh.
2 ml inh.	2 ml inh.	0	0.7 ml inh. (pink)	2 ml sol. w.	1.5 ml inh.
3 ml sol.	2 ml inh.	0.5 ml sol.	0.7 ml inh.	1 ml sol. on st. 3′	1 ml sol.
			2 ml inh. 0.5 ml inh.	2 ml sol.	
		0.5 ml sol. r.cl. on w. red	0	1 ml sol. r.cl. on w.	1 ml sol.
		0.5 ml sol. (red. viol.)	2 ml inh. yellow	0.5 ml sol. on st. 5′	1 ml sol.
1 ml sol.	0.6 ml sol.	0.5 ml sol. (red. viol.)	0.4 ml sol.	0.5 ml sol.	0.6 ml sol.
		0.5 ml sol.	1 ml sol.	0.25 ml sol. on st.	0.5 ml sol.
1.5 ml sol.	3 ml inh.	0.2 ml sol.	0.3 ml sol.	0.2 ml sol.	0.2 ml sol.
2 ml sol. on st. 3′	2.5 ml sol. (alm. colorless)	1 ml sol.	2.5 ml sol.	1.5 ml sol.	1.5 ml sol.
2 ml inh.	2 ml inh.		1 ml inh.		1 ml inh.
		2 ml sol. on st. 10′ (pink.)	2 ml inh. (pink)		
0.5 ml sol. (pale green)		0.5 ml sol. pink	0.5 ml sol. pink	0.5 ml sol.	0.5 ml sol.

TABLE

SILICATES

Sub-

Solvent	$CuSiO_3$*	$MgSiO_3$*	$CaSiO_3$*	$ZnSiO_3$	$Al_2(SiO_3)_3$
M MP	0.8 ml sol. colorless	0.5 ml sol.	0.5 ml sol.	1 ml sol.	1.5 ml inh.
M PP	0.5 ml sol. green	1.5 ml sol.	0.5 ml sol.	0.5 ml sol.	1.5 ml inh.
M/2 TP	0.5 ml sol. green	1.5 ml sol.	0.5 ml sol.	0.5 ml sol.	1.5 ml inh.
M EMP	0.5 ml sol. green	0.5 ml sol.	0.5 ml sol.	0.5 ml sol.	1.5 ml inh.
M NaG	1.5 ml inh. after 1′ t.	3 ml sol. w.	2 ml sol.	1.5 ml inh.	1.5 ml inh.
5% RN	1.5 ml inh.	1 ml sol.	1 ml sol.	1.5 ml sol.	1.5 ml inh.
10% Na Cel.		1 ml sol. w. 2 ml sol.	2 ml sol.	1 ml sol.	
M Na Gal.		0.5 ml sol.	0.5 ml sol.		
M Na Asc.		1 ml sol. on w. t.	1 ml sol.	0	2 ml inh.
M Na Gluc.		1 ml sol. on st. 5′	1 ml sol.	1.3 ml inh.	2 ml inh. r.cl. on w.
M Na Gl.		0.5 ml inh. r.cl. 24 h	1 ml sol.		
M Na Pyr.		0.5 ml sol. on st. after ½ h t.	0.5 ml sol. on w. t.	1 ml sol.	
M NH_4-Lac.		0.2 ml sol.	0.5 ml sol.		
M Na-Lac.		1 ml sol.	1 ml sol.		
M NH_4 Ch.S.		1 ml sol. r.cl. on w.	1 ml sol.		
M Na Mal.					

* C. 1 ml H_2O ppt.
** C. 2 ml H_2O ppt. All solutions colorless.

Experiments were also carried out with *M* Na-glycolate, 1.5 *M* K-tartrate, *M* Na-carboxymethylmercaptosuccinate*** (resemblance with citric acid) and 6% Na-desoxyribonucleate. The results were analogous.

*** H_2C–COOH
|
HC–COOH
|
S
|
H_2C–COOH

VIII

strate

$PbSiO_3$	$MnSiO_3$	$FeSiO_3$*	$Fe_2(SiO_3)_3$**	$CoSiO_3$	$NiSiO_3$
		1 ml sol.	1.4 ml sol. w.	1 ml sol. (alm. colorless)	1.5 ml sol. w.
		2 ml sol.	1.4 ml sol. w.	1 ml sol. w. (blue)	1 ml sol. w. on st. 2′
		1.5 ml sol.	2 ml sol. w.	1 ml sol. (pink)	1.5 ml sol. w. on st.
		0.5 ml sol. on st.	1.4 ml sol.	0.8 ml sol. (pink)	1 ml sol. w.
		3 ml inh.	3.4 ml inh.	1.5 ml inh. (pale pink)	1.5 ml inh.
		3 ml inh. (green)	2 ml inh.	1.5 ml inh.	1.5 ml inh.
		2 ml sol.			
		0.3 ml sol.	0		
	1.3 ml inh.				
	0.6 ml sol.				0.4 ml sol. w.
4 ml sol.					0.1 ml sol. on w. flakes of SiO_2
5 ml sol.	2.5 ml sol.				2.5 ml sol.
		2 ml inh.			
		2 ml inh.			

TABLE IX

PHOSPHITES AND AZIDES

Substrate	Solubilizing agents: M MP	M PP	M/2 TP	M EMP	M NaG	5% RN	M/4 Mg Gl.	M/4 MFP	Remarks
Hg_2HPO_3	0.5 ml inh. pH 5, at pH 7 slig. t. (reduct.)	0.5 ml sol.	0.5 ml sol.	0.5 ml sol.	o	o	0.75 ml inh. pH 5, at pH 7 t. (reduct.)		
$PbHPO_3$	1 ml sol. w.	0.5 ml sol.	1 ml sol.	0.5 ml sol. w.	1.5 ml inh. slig. t.	1.5 ml inh. at pH 5, on w. at pH 7, slig. t.			2 ml H_2O dissolve slig.
	(Most of the other metal phosphites are not precipitated under the prevailing conditions)								
HgN_3	0.3 ml inh.	0.1 ml sol.	0.4 ml sol. w.	0.1 ml sol.	0.2 ml sol. w.	0.2 ml sol. w. after 5′ st.		0.2 ml o	
AgN_3	1 ml sol. w.	0.6 ml sol. w.	0.2 ml sol. w.	0.2 ml sol.		0.2 ml sol. w.		0.2 ml o	
$Pb(N_3)_2$	0.4 ml sol.	0.05 ml sol.	0.2 ml sol.	0.05 ml sol.		0.3 ml inh. cl. in acid or NH_4OH on addition of Na_2CO_3 ppt.			

TABLE X

SULFITES

Substrate	Solubilizing agents: M MP	M PP	M/2 TP	M EMP	M NaG	5% RN	Remarks
$CaSO_3$	0.4 ml sol. w.	0.4 ml sol. w.	0.2 ml sol. w.		0.6 ml inh. ppt. on w.	0.6 ml inh. r.cl. on w.	ppt. only on warming.
$BaSO_3$	0.7 ml inh.	1 ml inh. slig. t.	0.7 ml inh.	1 ml inh. on st. t.	0.7 ml inh. alm. cl.	0.7 ml inh.	because of the presence of H_2SO_4 only the inh. is possible C. with 5 ml H_2O ppt.
$PbSO_3$	2 ml sol. w.	1 ml sol.	2 ml sol. w.	2 ml sol. w.	3 ml inh. slig. t.	3 ml inh. on st. t.	C. with 3 ml H_2O ppt.
$MnSO_3$	0.1 ml sol.	0.1 ml sol.	0.1 ml sol.	0.1 ml sol. on st. t.	0.2 ml sol.	0.4 ml sol.	ppt. only on w. C. with 0.4 ml H_2O thick flaky ppt. sol. in 1 drop *M* PP.
$CoSO_3$	0.2 ml sol. (pink)	0.2 ml sol. (blue-viol.)	0.1 ml sol. (pink-viol.)	0.1 ml sol. (blue-viol.)	0.2 ml sol. w. (pink)	0.4 ml sol. w. somewhat t. at pH 7, cl. at pH 8	ppt. only on w. or on st. after 3′. C. with 1 ml H_2O flaky emerald green ppt.

TABLE XI

TELLURITES AND TELLURATES, SELENITES AND SELENATES

	Solubilizing agents						
Substrate	*M MP*	*M PP*	*M/2 TP*	*M EMP*	*M NaG*	*5% RN*	*Remarks*
$MgTeO_3$	0.1 ml sol.	0.1 ml sol.	0.1 ml sol.	0.1 ml sol.	0.3 ml sol.	0.3 ml inh.	C. insol. in 0.3 ml H_2O
$BaTeO_3$	0.4 ml sol. w.	$BaCl_2$ ppt. with *M* PP	0.4 ml sol.	$BaCl_2$ ppt. with *M* EMP	0.4 ml sol. w.	0.4 ml inh.	C. insoluble in 1 ml H_2O ppt. heavier on warming
$MgTeO_4$	1 ml sol.	0.5 ml sol.	0.5 ml sol.	0.5 ml sol.	2 ml sol.	1.5 ml sol.	
$CaTeO_4$	0.5 ml sol.	0.5 ml sol.	0.5 ml sol.	0.5 ml sol.	2 ml sol. w.	1 ml sol. w.	
$BaTeO_4$	0.5 ml sol.	0.5 ml sol.	0.5 ml sol.	0	2 ml sol.	2 ml sol.	
	Cu, Co, Zn, Ni, UO_2 tellurates are insoluble in all mentioned solubilizing agents with the exception of *M*/2 TP. In *M*/2 TP sol. w. at pH 8. Ferrous tellurate is insoluble in all agents.						
$CuSeO_3$	0.5 ml sol. (colorless)	0.5 ml sol.	0.5 ml sol. (blue)	0.5 ml sol. (blue)	1.5 ml inh.	1.5 ml inh.	
$CaSeO_3$	0.25 ml sol.	0.25 ml sol.	0.75 ml sol. w.	0.5 ml sol. w.	1.5 ml sol. w.	1.5 ml inh.	
$ZnSeO_3$	0.5 ml sol.	0.5 ml sol.	0.5 ml sol.	0.5 ml sol.	0.5 ml sol.	1 ml inh.	
$BaSeO_3$	0.5 ml sol.	1 ml sol. w. on st. 3′	1.5 ml sol. w. on st. 3′	1.5 ml inh.	1.5 ml inh.	1.5 ml inh.	
$(UO_2)SeO_3$	1.5 ml sol. w.	1 ml sol.	1 ml sol. on st. 3′	1 ml sol. on st. 3′	1 ml sol. w.	1 ml inh. r.cl. 30′	
$CoSeO_3$	0.5 ml sol. (pink)	0.5 ml sol.	0.5 ml sol. (pink)	0.5 ml sol. (pink)	1.5 ml sol. w. (pink)	1.5 ml sol. w. (pink)	
$BaSeO_4$	1.5 ml inh.	1.5 ml inh.	1.5 ml inh.	1.5 ml inh.	1.5 ml inh.	1.5 ml inh.	

TABLE XII

MERCAPTIDES

Solubilizing agents

Substrate	*M MP*	*M PP*	*M/2 TP*	*M EMP*	*M NaG*	*5% RN*	*Remarks*
$Ni(C_7H_4NS_2)_2$	0.5 ml sol. w. 0.5 ml inh. (colorless)	1 ml sol. w. 0.5 ml inh. (colorless)	2 ml sol. w. 0.5 ml inh. (colorless)	0.5 ml inh. (colorless)	2 ml inh. (colorless)	4 ml sol. on st. 4 h 1 ml inh.	Solutions in: MP resistant to Na_2S; PP resistant to Na_2S only short time; TP resistant to Na_2S only short time; EMP resistant to Na_2S only short time; NaG not resistant to Na_2S; RN not resistant to Na_2S Sequence: first $NiSO_4$, then sol. agent then MBTh. C. 4 ml H_2O ppt.
$Co(C_7H_4NS_2)_2$	2 ml sol. w. (yellowish)	2 ml sol. on st. 3′ (yellow-green)	2 ml sol. w. (alm. colorless)	2 ml sol. w. (alm. colorless)	2 ml sol. incomplete 2 ml inh. (greenish)	2 ml sol. incomplete 2 ml inh.	C. green ppt.
$Fe(C_7H_4NS_2)_2$	1 ml sol. w. (colorless)	0.5 ml sol.	1 ml sol. w.	2 ml sol. w.	2 ml sol. (greenish)	2 ml sol. w.	C. yellowish ppt.
$Fe_2(C_7H_4NS_2)_2$	2 ml sol. w. (yellow)	1 ml sol. (yellow)	2 ml sol. w. (yellow)	2 ml sol. w. (yellowish)	2 ml sol. w. (orange)	3 ml inh.	C. orange ppt.
$Cu(C_7H_4NS_2)_2$	o	2 ml inh. (alm. colorless)	o	o	o	3 ml inh. (green)	C. gray ppt.
$Zn(C_7H_4NS_2)_2$	1 ml sol. w.	0.5 ml sol.	1 ml sol.	1 ml sol.	3 ml inh. incomplete	2 ml inh.	C. white ppt.

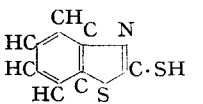
The odorless 2-mercaptobenzothiazol (MBTh) has been used in these experiments 

TABLE XIII

ARSENATES AND TETRABORATES

Solubilizing agents

Substrate	*M MP*	*M PP*	*M/2 TP*	*M EMP*	*M NaG*	*5% RN*	*Remarks*
NH_4MgAsO_4	0.1 ml sol.	0.1 ml sol.	0.2 ml sol.	0.2 ml sol.	0.3 ml sol.	0.2 ml sol.	ppt. centrifuged, washed 3 times
NH_4MgAsO_4	0.2 ml inh.	0.2 ml inh.			0.2 ml inh.		ppt. not washed
Ag_3AsO_4	0	0	0	1 ml inh.	0	1 ml inh.	
$(UO_2)_3(AsO_4)_2$	3 ml inh.	3 ml sol. w.	3 ml sol. w.	3 ml inh.	3 ml inh.	5 ml inh.	
$Ag_2B_4O_7$	1 ml sol.	0	0	1 ml sol.	0	1 ml sol.	
CaB_4O_7	0.4 ml sol.	0.3 ml sol.	0.5 ml sol.	0.3 ml sol.	0.8 ml sol.	0.8 ml sol.	
HgB_4O_7	1.5 ml inh.	1.5 ml inh.	1.5 ml inh.	0.5 ml sol.	1.5 ml sol. w.	1 ml sol.	
PbB_4O_7	0.5 ml sol.	0.3 ml sol.	0.5 ml sol.	0.5 ml sol.	1.5 ml inh. 0	1.5 ml inh.	

TABLE XIV

ORTHO- AND META-VANADATES AND VANADYLPHOSPHATE

Solubilizing agents

Substrate	*M MP*	*M PP*	*M/2 TP*	*M EMP*	*M NaG*	*5% RN*	*Remarks*
$Cu_3(VO_4)_2$	1 ml sol.	0.25 ml sol.	1 ml sol.	1 ml sol.	4 ml partly sol. w.	4 ml sol. w.	
Ag_3VO_4	0	0	0	4 ml sol. w.	0	3 ml inh.	
$Ba_3(VO_4)_2$	1 ml sol.	1 ml sol.	1 ml sol.	1 ml sol.	3 ml sol. w.	4 ml inh.	
Hg_3VO_4	0						
		1 ml sol.	4 ml sol.	0	0	2 ml inh.	
$Pb_3(VO_4)_2$	0	1 ml sol.	5 ml sol. w.	2 ml sol. w.	0	4 ml inh.	
$(UO_2)_3(VO_4)_2$	3 ml inh.	2 ml sol. w.	3 ml inh.	3 ml sol. w.	4 ml inh.	3 ml inh.	
$Mn_3(VO_4)_2$	1 ml sol.	0.5 ml sol.	0.5 ml sol.	1 ml sol.	4 ml sol. w.	3 ml sol.	all solutions colorless, only in TP slig. pink;
$Co_3(VO_4)_2$	1 ml sol.	0.25 ml sol.	0.5 ml sol.	0.5 ml sol.	3 ml sol. w.	1.5 ml sol.	all solutions pinkish-violet.
$Ni_3(VO_4)_2$	0.5 ml sol.	0.3 ml sol.	0.5 ml sol.	0.5 ml sol.	4 ml sol. w.	3 ml sol.	
$Cu(VO_3)_2$	0.6 ml sol.	0.4 ml sol.	0.5 ml sol.	0.3 ml sol.	0	2 ml sol.	MP, TP, RN yellowish-green solutions, EMP green.
$HgVO_3$	0	0.5 ml sol.	3 ml sol.	0.75 ml sol.	0	0	
$Pb(VO_3)_2$	3 ml inh. t.	0.8 ml sol.	3 ml sol.	1 ml sol.	0	3 ml inh.	
$(VO)_3(PO_4)_2$	1.5 ml sol. w.	1.5 ml sol.	2 ml sol. w.	2 ml sol.	5 ml sol. w.	3 ml sol. w.	

TABLE XV

TUNGSTATES AND MOLYBDATES

Solubilizing agents

Substrate	*M MP*	*M PP*	*M/2 TP*	*M EMP*	*M NaG*	*5% RN*	*Remarks*
Ag_2WO_4	3 ml inh. alm. cl.	o	o	2 ml sol.	o 3 ml inh. t.	3 ml inh.	
$BaWO_4$	2.5 ml inh.	1.5 ml inh.	2.5 ml inh.	2.5 ml inh.	2.5 ml inh.	2.5 ml inh.	
Hg_2WO_4	2 ml sol. w.	1 ml sol.	1 ml sol.	reduction	4 ml sol. w.	reduction	
$PbWO_4$	2 ml sol. w.	0.75 ml sol.	1 ml sol.	1 ml sol. w.	o	3 ml inh.	
$FeWO_4$	1 ml sol. (colorless)	0.5 ml sol.	1 ml sol. (colorless)	0.5 ml sol. (colorless)	4 ml sol. w. (yellow)	3 ml inh.	
$BaMoO_4$	3 ml alm. sol. w.	2 ml sol. w.	3 ml alm. sol.	3 ml alm. sol.	3 ml inh.	3 ml inh.	
Hg_2MoO_4	3 ml sol. w.	1 ml sol.	2 ml sol.	reduction	o 3 ml inh. t.	3 ml inh. pH 5, at pH 7 reduction	Reduction means discoloration by formation of mercury.

TABLE XVI

IODATES

Solubilizing agents

Substrates	*M MP*	*M PP*	*M/2 TP*	*M EMP*	*M NaG*	*5% RN*	*Remarks*
$AgIO_3$	3 ml sol. w.	o	5 ml sol. w.	3 ml sol.	3 ml sol.	3 ml sol.	Ag and Hg are ppt. with KIO_3
$HgIO_3$	2 ml sol.	2 ml sol.	2 ml sol.	2 ml sol.	3 ml inh. only for a moment r.cl.	3 ml inh. on st. t. after 2′	
$Cu(IO_3)_2$	0.2 ml sol. pH 6, at pH 8 t, on w. cl., (alm. colorless)	0.1 ml sol. (blue)	0.1 ml sol. (blue)	0.1 ml sol. (blue)	0.3 ml inh. (blue-green)	0.3 ml inh. (blue-green)	Cu, Ba, Pb, Th are ppt. with $NaIO_3$.
$Ba(IO_3)_2$	0.3 ml sol. w.	o	0.5 ml sol. w.	o	0.3 ml sol. w.	0.3 ml inh.	Ca, Mg, Cu, Zn, Co, Cd do not form ppt's with KIO_3. Pb ppt. with KIO_3, but is sol. in warm H_2O.
$Pb(IO_3)_2$	0.4 ml sol.	0.2 ml sol.	0.4 ml sol.	0.4 ml sol. on st. 5′ t.	0.4 ml sol. w. on st. 10′ t.	o	
$Th(IO_3)_4$	0.3 ml inh. on w. t.	0.5 ml sol. w.	0.5 ml sol. w.	0.3 ml inh. o, clears on w.	0.5 ml sol. w.	o	

TABLE XVII

OXALATES

Solubilizing agents

Substrate	*M MP*	*M PP*	*M/2 TP*	*M EMP*	*M NaG*	*5% RN*	*M Na-Glyc.*	*M Na-Mal.*	*M Na-Gluc.*	*Remarks*
$Ca(COO)_2$	1 ml sol.	1 ml sol.	1 ml sol.	1 ml sol. after 5′	3 ml sol. w.	4 ml sol. w.	2 ml sol. w. pH 8	2 ml sol. w.	2 ml inh. r.cl. pH 8	C. 2 ml H_2O o C. 0.5 ml H_2O t.
$Y_2[(COO)_2]_3$	2 ml sol.	1 ml sol.	1 ml sol.	2 ml sol.	2 ml sol. w.	3 ml inh.				
$La_2[(COO)_2]_3$	2 ml sol.	1 ml sol.	1 ml sol.	1 ml sol.	3 ml inh. after st. somewhat t.	3 ml inh. somewhat t. clears quickly				
$Ce_2[(COO)_2]_3$	2 ml sol.	2 ml sol.	2 ml sol.	2 ml sol.	3 ml inh. after 10′ t.	3 ml inh. t. clears quickly, on st. again t.				
$Pb(COO)_2$	0.5 ml sol.	0.5 ml sol.	0.5 ml sol.	0.5 ml sol.	2 ml alm. sol. w.	3 ml alm. sol. w.				
$Th[(COO)_2]_2$	2 ml sol. w.	1 ml sol.	1 ml sol. w.	2 ml alm. sol. w.	3 ml sol. w.	o				
$Pr_2[(COO)_2]_3$	2 ml sol. w.	1.5 ml sol.	2 ml sol.	2 ml sol.	3 ml alm. sol. w.	3 ml inh. on st. at pH 6, t. clears at pH 8, on st. again t.				
$Nd_2[(COO)_2]_3$	2 ml sol.	1.5 ml sol.	2 ml sol.	2 ml sol.	3 ml inh.	3 ml inh. after 5′ t. at pH 6, at pH 8 alm. clear.				

TABLE XVIII

FERROCYANIDES

Solubilizing agents

Substrate	*M MP*	*M PP*	*M/2 TP*	*M EMP*	*M NaG*	*5% RN*	*Remarks*
$Cu_2Fe(CN)_6$	3 ml sol. w. (yellowish)	2 ml sol.	2 ml sol. (slig. green)	2 ml sol. w. (slig. green)	o	3 ml inh. (ruby red)	
$Zn_2Fe(CN)_6$	4 ml alm. sol. w.	1 ml sol.	2 ml sol.	2 ml sol.	3 ml inh. w.	3 ml inh.	
$Cd_2Fe(CN)_6$	3 ml sol. w.	2 ml sol. w.	1 ml sol. w.	2 ml sol. w.	o	3 ml inh. w. on st. 5′	
$TiFe(CN)_6$	1 ml sol. at pH 7, at pH 9 t.	0.5 ml sol.	0.5 ml sol.	0.5 ml sol.	1 ml sol.	2 ml inh.	ppt. insol. in 2 ml H_2O or CH_3COONa
$Pb_2Fe(CN)_6$	2 ml sol.	0.5 ml sol.	1 ml sol.	1 ml sol.	o	3 ml inh.	
$ThFe(CN)_6$	3 ml sol. w.	0.5 ml sol.	1 ml sol.	2 ml sol. w.	2 ml sol.	o	
$Bi_4[Fe(CN)_6]_3$ (*M*/100)	2 ml sol.	1 ml sol.	1 ml sol.	1 ml sol.	2 ml sol.	o	ppt. insol. in 2 ml H_2O or Na_2CO_3
$(UO_2)_2Fe(CN)_6$	2 ml sol. w.	1.5 ml sol. w. (light-yellow)	2 ml sol. w.	2 ml sol. w.	2 ml inh.	3 ml inh. w.	
$Mn_2Fe(CN)_6$	2 ml sol.	3 ml sol. w.	1 ml sol.	2 ml sol. w.	o	o	
$Co_2Fe(CN)_6$	3 ml inh. (colorless)	2 ml sol. w. (blue-viol.)	2 ml sol. (pink)	3 ml inh. (alm. colorless)	o	3 ml inh. on st. 3′ t.	
$Ni_2Fe(CN)_6$	3 ml inh.	2 ml sol. w. after 2′	2 ml alm. sol. w.	3 ml alm. sol. w.	o	3 ml inh.	

TABLE XIX

ALKALOID SALTS (PRECIPITATED WITH BISMUTH IODIDE-POT. IODIDE REAGENT)

	Solubilizing agents						
Substrate M/100	*M MP*	*M PP*	*M/2 TP*	*M EMP*	*M NaG*	*5% RN*	*Remarks*
Quinine HCl	3 ml alm. sol. on st. t. (pale orange)	2 ml sol. w. on st.	3 ml alm. sol. (pale orange)	2 ml sol. (colorless)	2 ml slig. t.	2 ml sol. w.	
Brucine HCl	1 ml alm. sol. on st. t.	1 ml sol.	1 ml sol. on st. t.	1 ml sol.	3 ml alm. sol.	2 ml sol. w.	all solutions pale yellow with NaG colorless
Nicotine sulfate	1 ml sol.	1 ml sol.	1 ml sol.	1 ml sol.	2 ml sol. on st. t.	2 ml sol. w.	all solutions pale yellow
Strychnine sulfate	2 ml sol. on st. t. (colorless)	1 ml sol. w. after 5′ (cryst. ppt.)	2 ml alm. sol. w. (yellow)	2 ml sol. (colorless)	2 ml sol. w. turns t. at once	2 ml sol. w.	
Quinidine bisulfate	2 ml sol. w. at pH 7, at pH 8 t.	1 ml sol. w.	2 ml sol. w. on st. t.	1 ml sol. w.	0	2 ml sol. w.	

TABLE XX

ALKALOID SALTS (PRECIPITATED WITH PHOSPHOMOLYBDIC ACID REAGENT)

	Solubilizing agents						
Substrate M/100	*M MP*	*M PP*	*M/2 TP*	*M EMP*	*M NaG*	*5% RN*	*Remarks*
Nicotine sulfate	2 ml sol. w. (colorless)	1 ml sol. (colorless)	2 ml sol. (colorless)	2 ml sol. (bluish)	2 ml sol. slig. t. at pH 6, cl. at pH 9 (colorless)	2 ml sol. w.	C. with 2 ml H_2O ppt. which apparently increases on warming; not dissolved even with 3 ml of H_2O.
Strychnine sulfate	2 ml inh.	2 ml sol. w.	2 ml sol. w.	2 ml sol. w.	2 ml sol. w.	2 ml inh.	all solutions colorless
Quinine HCl	2 ml alm. sol.	1 ml sol. w.	2 ml alm. sol. on w. t.	2 ml sol.	2 ml alm. sol. on w. cl.	2 ml alm. sol.	
Quinidine bisulfate	2 ml inh. slig. t.	1 ml sol. w.	2 ml alm. sol. w.	1 ml alm. sol. w.	2 ml alm. sol. w.	1 ml inh.	C. ppt. does not dissolve with 3 ml H_2O, not even on warming.

Experiments were also carried out with the alkaloids ppt. with cadmium iodide-sod. iodide reagent and with phosphotungstic acid reagent. The results obtained were analogous.

TABLE XXI

OVALBUMIN*-PRECIPITATES

Solubilizing agents

Substrate	*M MP*	*M PP*	*M/2 TP*	*M EMP*	*M NaG*	*5% RN*	*M/4 Mg Gl.*	*Remarks*
Ovalbumin chondroitin sulfate	0.5 ml sol. pH 5	0.1 ml sol. pH 5	0.2 ml sol. pH 5		0.5 ml sol. pH 5	1 ml inh. as follows 1 ml Ch.S. 1 ml RN 1 drop $M/10$ NH_4OH, 1 ml CH_3COOH, alm. sol., on st. t. with 1 drop $M/10$ NH_4OH cl., pH 5	2 drops 4 M NH_4OH 1 ml sol. pH 5	0.15 ml 10% CH_3COOH is added at ppt. C. 1 ml H_2O with 2 drops 4 M NH_3 t. The egg albumin nucleate ppt. is dissolved by Ch.S. at pH 6 to 6.5
Ovalbumin Pot. iodide Bismuth iod. ppt.	6 ml inh. pH 6 at pH 9 slig. t.	6 ml inh.	6 ml inh.	6 ml inh.	6 ml inh. pH 6, r.cl. up to pH 10	6 ml inh. pH 4 r.cl. up to pH 10		C. H_2O, CH_3COONa, Na_2HPO_4 all ppt.
Ovalbumin Na iodide Cadmium iodide ppt.	2 ml sol. on st. t.	2 ml sol.	2 ml sol.	2 ml sol.	4 ml sol. pH 7, at pH 9 slig. t.	4 ml sol. pH 5, r.cl. up to pH 9		C. as above

For the experiments 1 ml of 0.5% Ovalbumin solution was used.

Solubilization of other protein ppts.

Salmine chondroitin sulfate is soluble in Na ribonucleate at pH 5, r.cl. on adding CH_3COOH, on w.t., on cooling clear again.

On the other hand the ppt. of the Protamine ribonucleate is soluble in the NH_4 salt of Ch.S.

Bovine Plasma Albumin desoxyribonucleate dissolves easily in the neutral NH_4 salt of Ch.S. Even large amounts dissolve on st. at pH 5.5 to 7; it is also soluble in Na pyruvate. The precipitate is formed on addition of 10% CH_3COOH. 10% CH_3COOH alone does not ppt. the albumin.

Protamine nucleate dissolves in an excess of Na ribonucleate, the ppt. is not soluble in Na pyruvate at neutral or slightly alkaline pH, it dissolves incompletely in M MP, on w., likewise in M PP, not soluble in $M/2$ TP, M EMP.

Ovalbumin-ribonucleate is easily soluble in M Na malate at pH 5.5 to 7.5.

Ovalbumin-desoxyribonucleate: analogous.

* Prepared according to R. K. CANNAN *et al.*, *Bioch. J.*, 30 (1936) 227.

TABLE XXII

NUCLEATES

Substrate	*Solvent* 10% *Sodium celluronate*	*Remarks*
Ca-nucleate	2 ml inh. pH 7.2 r. cl. on w.	C. 2 ml H_2O clear, turbid on w., remains t. on cooling
Al-nucleate	1 ml sol. w. pH 6 r. cl. up to pH 8	Ca-nucleate sol. by *M* Na malate at pH 5.5–7.5
La-nucleate	1 ml inh. pH 6 r. cl. at pH up to 8	
Ce-nucleate	1 ml sol. on st. 3′ pH 8	
UO_2-nucleate	1 ml sol. pH 6 r. cl. at pH up to 8	
Ferric-nucleate	1 ml sol. on sh. pH 5 r. cl. up to pH 7.5	
M/100 Quinine nucleate	sol. r. cl. up to pH 7	
M/100 Strychnine nucleate	sol. r. cl. up to pH 7.5	

TABLE XXIII

VARIA

Ferricyanides and Cobalticyanides: results are analogous to those obtained with Ferrocyanides.

Gallium: $Ga(OH)_3$ and $Ga_4[Fe(CN)_6]_3$ are solubilized by *M* PP, *M*/2 TP, and *M* NaG.

Magnesium fluorophosphate: The precipitation of Na-fluorophosphate by Mg-acetate is delayed on previous addition of 5% RN or 6% DRN.

Alginates: Cu-, Mg-, Ca-, Al-, Mn-, Fe(II)-alginates are solubilized by *M* MP, *M* PP, *M*/2 TP, *M* EMP, *M* NaG and 5% RN. Mercurous alginate is solubilized by *M* MP, *M* PP, *M*/2 TP, *M* Na Pyr. on warming.

Pectates: Mg-, Ca-, Al-, Fe(II), Fe(III), Mn-pectates are solubilized by *M* MP, *M* EMP, 5% RN.

Calcium humate: prepared from the soluble Na- or NH_4-salt. Typical turbidity on warming. The precipitation is inhibited when *M* MP, *M* PP, *M*/2 TP or *M* EMP are previously added.

Basic Calcium-gluconate is solubilized by *M* Na malate and 5% RN; pH 11.

Calcium-fructose-diphosphate: This compound is soluble in cold and insoluble in hot water. Notoriously a suspension of the insoluble Ca-salt redissolves on cooling. The hot-precipitation is inhibited on addition of many inorganic and organic "solvents" which are mentioned before.

In a similar manner the precipitation of numerous naturally occurring acids by *salts of alkaline earth and rare earth metals* (Ce, La, Y, Pr, Nd etc.) is prevented.

8-*Hydroxyquinoline compounds:*

Precipitation of
- Cu-compound: inh. with 5% RN.
- Zn-compound: inh. with *M*/2 TP and 5% RN.
- Co-compound: inh. with *M*/2 TP and 5% RN.
- Ni-compound: inh. with *M* EMP and 5% RN.

Alkali salts of propanediol phosphoric acid, 5-phospho-D-arabonic acid, phytic and 3-phospho-D-glyceric acid have been proven as good "solvents".

Part of the description of the phenomena under consideration may be amplified by the statement that neutral salts are now found capable of accomplishing in a far more general way tasks previously assigned to a limited extent to free acids or alkalis. The exact mechanism involved must naturally differ for various types of reacting substances. The effects due to multifunctional groups, auxiliary valences, intra- and intermolecular and interionic forces, association, simple addition and coordination compounds, chelates, molecular compounds and aggregates of higher order, clathrates, all play a part. Experiments dealing with the various systems will be reported in a later communication.

SUMMARY

It could be shown that the salts of inorganic acids, and especially of a great number of organic acids are capable of solubilizing insoluble mineral constituents and organic materials, or of preventing their precipitation. These compounds are formed from elements which belong to all the groups of the periodic system and to the most different classes. The solvents are found everywhere; they are obligatory intermediaries, continually reformed, or final products of metabolism, or cellular constituents. They perform at the same time the function of carrier of the solubilized material. The transformation products of materials of high molecular weight which can form salts are often excellent solvents. The general importance of these phenomena is discussed.

RÉSUMÉ

Les auteurs ont montré que les sels d'acides inorganiques et surtout de nombreux acides organiques sont capables de rendre solubles des constituants minéraux et des matières organiques insolubles ou d'empêcher leur précipitation. Ces composés peuvent contenir des éléments appartenant à tous les groupes du système périodique et faire partie des classes de corps les plus diverses. Les "solvents" se trouvent partout: ce sont des intermédiaires obligatoires, reformés continuellement, ou des produits finaux du métabolisme, ou bien des constituants cellulaires. Ils remplissent en même temps la fonction de véhicule de la matière solubilisée. Les produits de transformation de matières à poids moléculaire élevé qui peuvent former des sels sont souvent des excellents solvents. L'importance générale de ces phénomènes est discutée.

ZUSAMMENFASSUNG

Für Salze anorganischer und namentlich zahlreicher organischer Säuren wird die Fähigkeit nachgewiesen, unlösliche Mineralbestandteile und unlösliche organische Materialien in Lösung zu bringen oder vor dem Ausfallen zu bewahren. Die Verbindungen können allen Gruppen des periodischen Systems und den verschiedensten Körperklassen angehören. Die Lösungsmittel sind ubiquitär, sie sind fortlaufend neu geschaffene obligatorische Zwischenstufen oder Enderzeugnisse des Stoffwechsels oder Zellbestandteile. Sie erfüllen zugleich Schlepperfunktionen für die solubilisierte Materie. Salzbildende Umwandlungsprodukte hochmolekularer Substanzen erweisen sich oft als treffliche Solventien. Die allgemeine Bedeutung dieser Erscheinungen wird dargelegt.

REFERENCES

1 I. MANDL, A. GRAUER AND C. NEUBERG, *Biochim. Biophys. Acta*, 8 (1952) 654.
2 C. NEUBERG AND I. MANDL, *Z. Vitamin-, Hormon- u. Fermentforsch.*, 2 (1948) 480;
C. NEUBERG AND I. S. ROBERTS, *Arch. Biochem.*, 20 (1949) 185;
C. NEUBERG AND I. MANDL, *Arch. Biochem.*, 23 (1949) 499;
See also L. FRANKENTHAL, I. S. ROBERTS AND C. NEUBERG, *Expt. Med. Surg.*, 1 (1943) 386.
3 F. EPHRAIM AND C. ROSETTI, *Helv.*, 12 (1929) 1026;
R. KLEMENT, *Z. physiol. Chem.*, 184 (1929) 133; 196 (1931) 140;
See also basic phosphates of Be, Mg, Zn, as described in the Handbook of Gmelin, and the derivatives of $P(OH)_5$, as discovered by L. ANSCHÜTZ, *Ann.*, 454 (1927) 78, 91.
4 CH. N. SHEPARD, *Am. J. Sci and Arts*, [3] 15 (1878) 49.
5 A. KORNBERG AND O. LINDBERG, *J. Biol. Chem.*, 176 (1948) 665, 1475; *ibid.*, 182 (1950) 779.
6 C. NEUBERG, A. GRAUER AND I. MANDL, *Enzymol.*, 14 (1950) 157.
7 R. N. BELL, *Abstr. of the 109th Meeting of the Am. Chem. Soc.*, Atlantic City April 1946, p. 8; *Ind. Eng. Chem.*, 39 (1947) 136;
E. THILO AND R. RÄTZ, *Z. anorg. Chem.*, 258 (1949) 33;
E. THILO, *Angew. Chem.*, 63 (1951) 508.
8 B. C. HALDER, *Nature*, 166 (1950) 744; *Current Sci. (India)*, 19 (1950) 244.
9 W. R. AMBERSON and assoc., *J. Biol. Chem.*, 181 (1949) 405.
10 M. KOHN, *Anal. Chim. Acta*, 3 (1949) 559.
11 L. v. LIEBERMANN, *Ber. chem. Ges.*, 21 (1888) 598; *Pflügers Arch.*, 47 (1890) 155;
M. B. HARDIN, *Carolina Agr. exp. Sta. Bull.*, No 8, New Series 1892, 10.
12 J. HELLER, S. KARPIAC AND L. ZUBIKOWA, *Nature*, 166 (1950) 187;
S. NIMIERKO AND W. NIMIERKO, *Nature*, 166 (1950) 268.
13 S. SPIEGELMAN AND M. D. KAMEN, *Cold Spring Harbor Symposium Quant. Biol.*, 12 (1948) 211.
14 L. BRACHET, *Symp. Soc. Exptl. Biol.*, 1 (1947) 207;
J. M. WIAME, *J. Biol. Chem.*, 178 (1948) 919.
15 B. INGELMAN AND H. MALMGREN, *Acta Chem. Scand.*, 4 (1950) 478.

[16] T. KITASATO, *Biochem. Z.*, 197 (1928) 257; 201 (1928) 206.
[17] C. NEUBERG AND K. P. JACOBSOHN, *Biochem. Z.*, 199 (1928) 498;
C. NEUBERG AND H. A. FISCHER, *Enzymologia*, 2 (1937) 241.
[18] B. INGELMAN AND H. MALMGREN, *Acta Chem. Scand.*, 3 (1949) 157.
[19] W. J. ELLIS and assoc., *Nature*, 165 (1950) 545.
[20] J. R. VAN WAZER AND D. A. CAMPANELLA, *J. Am. Chem. Soc.*, 72 (1950) 661.
[21] R. C. VOGEL AND H. PODALL, *J. Am. Chem. Soc.*, 72 (1950) 1420.
[22] C. NEUBERG AND H. A. FISCHER, *Enzymologia*, 2 (1937) 191, 360; *Compt. rend. trav. Lab. Carlsberg*, 22 (1938) 366;
BAMANN-MYRBÄCK, *Die Methoden der Fermentforschung*, 2 (1941) 1671.
[23] M. DAINTY, J. NEEDHAM, D. M. NEEDHAM and assoc., *J. Gen. Physiol.*, 27 (1944) 355;
F. BUCHTAL, A. DEUTSCH AND G. G. KNAPPERS, *Acta physiol. Scand.*, 8 (1944) 271; 11 (1946) 325;
W. F. H. M. MOMMAERTS, *J. Gen. Physiol.*, 31 (1948) 361;
W. VISNIAK, *Arch. Biochem.*, 26 (1950) 167.
[24] A. LAJTHA, *Enzymologia*, 14 (1950) 254.
[25] S. SCHWIMMER AND A. K. BALLS, *J. Biol. Chem.*, 170 (1949) 1063.
[26] TH. BERSIN AND S. BERGER, *Z. physiol. Chem.*, 283 (1948) 74.
[27] W. D. MCELROY, J. COULOMBRE AND R. HAYS, *Arch. Biochem.*, 32 (1951) 207.
C. C. LINDEGREN, *Prot. Nat. Acad. Sci.*, 34 (1948) 187.
[28] K. LANGHELD, *Ber. chem. Ges.*, 43 (1910) 1857; 45 (1912) 3760.
See also R. RÄTZ AND E. THILO, *Ann.*, 572 (1951) 173.
[29] K. MAURER, *Ber. chem. Ges.*, 62 (1929) 332.
[30] E. CHERBULIEZ AND H. WENINGER, *Helv.*, 29 (1947) 2006;
J. E. SEEGMILLER AND B. L. HORECKER, *J. Biol. Chem.*, 192 (1951) 175.
[31] H. R. SNYDER AND F. X. WERBER, *J. Am. Chem. Soc.*, 72 (1950) 2962, 2965;
G. NOWLIN, *J. Am. Chem. Soc.*, 72 (1950) 5754.
[32] C. NEUBERG AND J. WAGNER, *Biochem. Z.*, 171 (1926) 485; See also ref. 17.
[33] M. FRIED AND A. J. MACKENZIE, *Science*, 111 (1950) 493;
J. G. A. FISKELL, *Science*, 113 (1950) 244.
[34] S. BABA, *Proc. Imp. Acad. Tokyo*, 19 (1943) 70; *C.A.* 41 (1947) 6308.
[35] A. CHRISTIE, *N.Y. Acad. Sci.*, 50 (1950) 1283;
G. BEVELANDER, *The Biol. Bull.*, 94 (1948) 176; 102 (1952) 9.
[36] O. WARBURG AND W. CHRISTIAN, *Biochem. Z.*, 310 (1941) 384.
[37] F. A. NAJJAR, *J. Biol. Chem.*, 175 (1948) 281.
[38] F. A. NAJJAR, *Phosphorus Metabolism. A Symposium*, Vol. 1, p. 509, Baltimore 1951.
See also J. RUNSTRÖM AND E. SPERBER, *Biochem. Z.*, 298 (1938) 340.
[39] E. GÄUMANN, G. MIESCHER and assoc., *Phytopathol. Z.*, 16 (1950) 256.
[40] J. Z. HEARON, D. BURK AND A. L. SCHADE, *J. Nat. Cancer Inst.*, 9 (1949) 337.
[41] R. CAPUTTO, L. F. LELOIR and assoc., *Enzymologia*, 12 (1948) 355.
[42] L. M. WHEELER AND C. K. BANKS, *J. Am. Chem. Soc.*, 70 (1948) 1266.
[43] C. P. SIDERIS, *Plant Physiol.*, 25 (1950) 319.
[44] G. E. CARTWRIGHT AND M. M. WINTROBE, *J. Clin. Invest.*, 28 (1949) 86.
[45] J. COURTOIS AND C. ANAGNOSTOPOULOS, *Enzymologia*, 13 (1945) 183.
[46] S. H. HUTNER, *N.Y. Acad. Sci. Transact. Ser.*, II. Vol. 10 (1948) 136.
[47] TH. BERSIN, *Angew. Chem.*, 62 (1950) 246.
[48] A. FLERKENSTEIN AND W. JAEGER, *Arch. exper. Path. u. Pharmakol.*, 215 (1952) 163.
C. NEUBERG AND M. KOBEL, *Biochem. Z.*, 280 (1935) 297.
[49] R. STEINBERG, *J. Agr. Res.*, 57 (1938) 569.
[50] L. DE SAINT-RAT, *Compt. rend.*, 227 (1948) 150.
[51] H. WIELAND AND R. SONDERHOFF, *Ann.*, 499 (1932) 213;
H. WIELAND AND C. ROSENTHAL, *Ann.*, 554 (1943) 244.
[52] C. F. CORI, *Symposium on Respiratory Enzymes*, Madison 1942, p. 179.
[53] W. M. SEABER, *Analyst*, 58 (1933) 575.
[54] L. GENEVOIS, *Rev. Fermentations*, 6 (1951) 88; *Wallerstein Comm.*, 15 (1952) 99.
[55] C. R. B. BLACKBURN, *J. Biol. Chem.*, 178 (1949) 855.
[56] J. F. SPECK, *J. Biol. Chem.*, 178 (1949) 315;
R. U. BJERRUM and assoc., *Arch. Biochem.*, 26 (1950) 442.
See also W. J. HARTMAN AND G. KALNITSKY, *Arch. Biochem.*, 26 (1950) 6.
T. MIYAJI AND J. P. GREENSTEIN, *Arch. Biochem.*, 32 (1951) 414.
[57] M. HENZE, *Z. physiol. Chem.*, 72 (1911) 494; 86 (1913) 340.
See also D. A. WEBB, *J. Exp. Biol.*, 16 (1939) 499.
[58] D. BERTRAND, *Compt. rend.*, 215 (1942) 150, 205.
[59] J. CANTACUSÈNE AND A. TSCHEKERIA, *Compt. rend.*, 195 (1932) 486;
F. LOWATER AND M. M. MURRAY, *Biochem. J.*, 31 (1937) 837.

[60] A. TREIBS, *Ann.*, 517 (1935) 187; *Angew. Chem.*, 49 (1936) 682.
[61] P. PFEIFFER, H. THIELERT AND H. GLASER, *J. prakt. Chem.*, 152 (1939) 145.
See also R. A. WOODLE, *Chem. and Eng. News*, 30 (1952) 1522.
[62] N. L. SÖHNGEN, *Chem. Weekbl.*, 11 (1913) 240;
F. C. GERRETSEN, *Verslag Landb. Onderz.*, 42 A (1936) 57;
G. W. LEEPER AND R. J. SWABY, *Soil. Sci.*, 49 (1940) 163;
P. J. G. MANN AND J. H. QUASTEL, *Nature*, 158 (1946) 154;
H. G. DION, P. J. G. MANN AND S. G. HEINTZE, *J. Agr. Sci.*, 36 (1946) 239; 37 (1947) 17, 23;
V. D. SHERMAN AND S. M. BROMFIELD, *Nature*, 163 (1949) 575;
A. L. LEHNINGER, *Physiol. Rev.*, 30 (1950) 393.
[63] S. EDLBACHER AND H. BAUR, *Z. physiol. Chem.*, 254 (1938) 275; 259 (1939) 172.
[64] E. HOFMANN, *Biochem. Z.*, 320 (1950) 126;
E. HOFMANN AND K. BRÄUNLICH, *Z. Pflanzenbau u. Pflanzenschutz*, 3, Heft 2, 1952.
[65] P. PETIT, *Compt. rend.*, 116 (1893) 995;
A. KOCH AND A. OELSNER, *Biochem. Z.*, 134 (1923) 76.
[66] O. SCHREINER, *J. Am. Soc. Agr.*, 15 (1923) 117.
See also O. SCHREINER AND E. LATHROP, *U.S. Dept. Agr. Bur. Soils Bull.*, 89 (1913.
[67] E. C. SHOREY, *U.S. Dept. Agr. Bur. Soils Bull.*, 88 (1913);
W. B. BOTTOMLEY, *Proc. Roy. Soc., B* 90 (1919) 39.
[68] C. L. WRENSHALL, W. J. DYER AND G. R. SMITH, *Scient. Agric.*, 20 (1940) 266.
[69] R. K. YOSHIDA, *Soil Sci.*, 50 (1940) 81.
[70] E. R. WEIDLEIN JR., *Mellon Inst. Bibliogr. Ser. Bull.*, No 6 (1951) 12, Pittsburgh, Pa.
[71] C. F. ASENJO and assoc., *Puerto Rico J. Health and Trop. Med.*, 24 (1948) 44.
[72] C. NEUBERG AND A. GRAUER, *Enzymologia*, 15 (1951) 115.
[73] A. G. NORMANN, *Proc. Soil Sci. Soc., Am.*, 7 (1942) 7;
W. G. C. FORSYTH, *Chem. and Ind.*, (1948) 515;
W. G. C. FORSYTH AND D. M. WEBLEY, *Biochem. J.*, 44 (1949) 455.
[74] L. E. WISE, *Arch. Biochem.*, 23 (1949) 127.
[75] G. A. ADAMS AND A. E. CASTAGNE, *Can. J. Res.*, B. 27 (1949) 924;
C. T. BISHOP AND G. A. ADAMS, *ibid.*, B 28 (1950) 754.
[76] K. A. CLENDENING, *ibid.*, F. 26 (1948) 185.
[77] B. SYLVÉN, *Acta Chirurgica Scand.*, 86, Suppl. 66 (1941) 47; *Acta radiologica*, Suppl. 59 (1945); *J. Bone and Joint Surg.*, 29 (1947) 745; 30 (1948) 158; *Cancer Res.*, 8 (1948) 449; *Acta radiologica*, 32 (1949)11.
[78] C. NEUBERG, *Der Harn*, 1911, p. 788, Julius Springer, Berlin.
See also K. MEYER AND J. W. PALMERS, *J. Ophtalmol.*, 19 (1936) 353.
[79] G. E. PERLMANN, *Biochem. J.*, 32 (1938) 926, 931; *J. Biol. Chem.*, 137 (1941) 707.
See also D. R. BRIGGS, *J. Biol. Chem.*, 134 (1940) 261.
[80] P. OHLMEYER, *Biochem. Biophys. Acta*, 4 (1950) 229.
[81] O. WARBURG AND W. CHRISTIAN, *Biochem. Z.*, 303 (1939/1940) 57.
[82] D. GEBERS AND H. J. DEUTICKE, *Z. physiol. Chem.*, 284 (1949) 55.
[83] L. F. CAVALIERI, *J. Am. Chem. Soc.*, 74 (1952) 1242.
[84] J. W. FOSTER, S. F. CARSON and assoc., *Proc. Nat. Acad. Sci.*, 35 (1949) 663.
[85] K. BERNHAUER and assoc., *Biochem. Z.*, 320 (1950) 390.
[86] D. M. ENY, *Plant Physiol.*, 25 (1950) 478.
[87] K. V. THIEMANN AND W. D. BONNER JR., *Ann. Rev. Plant Physiol.*, (1950) 75.
[88] H. L. RILEY, *J. Chem. Soc.*, London (1929) 1307; (1930) 1642; (1934) 187, 1444.
[89] H. LUNDEGÅRDH AND G. STENDLID, *Ark. Botan.*, 31, No 3 (1944).
[90] J. BURKARD AND C. NEUBERG, *Biochem. Z.*, 270 (1934) 229.
[91] H. K. BARRENSCHEEN AND J. PANY, *Biochem. Z.*, 219 (1930) 364.
[92] I. MANDL AND C. NEUBERG, *Arch. Biochem.*, 33 (1951) 191.
[93] M. JOWETT AND J. H. QUASTEL, *Biochem. J.*, 29 (1935) 2143.
[94] a *Chem. Fabr.* J. A. BENKISER, *Abstr.*, 37 (1943) 3158.
b D. S. FLEMING, A. M. MOORE AND G. C. BUTLER, *Biochem. J.*, 45 (1949) 548.
c S. L. ROWLES AND L. A. STOKEN, *Biochem. J.*, 47 (1950) 491.
d K. M. DAOUD, *Biochem. J.*, 26 (1932) 255.
e L. HOLZAPFEL, *Naturwissenschaften*, 30 (1942) 185; 31 (1943) 386;
P. OHLMEYER AND U. OLPP, *Z. physiol. Chem.*, 281 (1944) 203.
f W. F. NEUMANN and assoc., *J. Biol. Chem.*, 179 (1949) 325.
g F. SCHEMINSKY AND W. GRABHERR, *Tschermaks mineral. u. petrograph. Mitt.*, [3], 2 (1951) 257, 282.
h C. VOEGTLIN AND H. C. HODGE, *Pharmak. and Toxicol. of Uranium compounds*, New York 1949, 70. Mc Graw-Hill Book Comp.
i P. FLEURY, *Compt. rend.*, 193 (1931) 1350; *J. Pharm. Chim.*, [8] 16 (1932) 333; *Bull. soc. chim.*, [4] 51 (1932) 637.
k H. WEIL-MALHERBE AND R. H. GREEN, *Biochem. J.*, 49 (1951) 286.

[l] J. R. PORTER, *Bact. Chemistry and Physiol.*, 620. New York, John Wiley & Sons, 1947.
[m] HARA RÉINUSUKÉ, *Bull. Chem. Soc. Japan*, 22 (1949) 225.
[n] MATUS, *Ber. Schweitzer botan. Ges.*, 58 (1948) 319.
[o] N. R. JOSEPH, *J. Biol. Chem.*, 164 (1946) 529.
[p] E. HEINZ, *Biochem. Z.*, 321 (1951) 314.
[q] C. H. WERKMAN AND P. W. WILSON, *Bact. Physiol.*, p. 514. Acad. Press, 1951;
See also H. NEURATH and assoc., *J. Am. chem. Soc.*, 74 (1952) 2122;
G. GOMORI, *Biochim. Biophys. Acta*, 8 (1952) 165.
[r] L. GORINI AND C. FROMAGEOT, *Compt. rend.*, 229 (1949) 559.
[s] M. BIER AND F. F. NORD, *Arch. Biochem. Biophys.*, 33 (1951) 320.
[t] M. B. HOAGLAND, *Arch. Biochem. Biophys.*, 35 (1952) 266.
[u] V. E. LEVINE, *Ann. N.Y. Acad. Sci.*, 26 (1915) 385;
J. G. FELS and assoc., *J. Biol. Chem.*, 176 (1948) 819; *Arch. Biochem.*, 22 (1949) 323.
[v] G. W. PUCHER AND H. B. VICKERY, *J. Biol. Chem.*, 163 (1946) 169.
[w] K. GORTER, *Rec.*, 31 (1912) 281;
H. FRANZEN AND F. SCHMITT, *Ber. chem. Ges.*, 58 (1925) 222;
F. CHALLENGER, V. SUBRAMANIAM AND T. K. WALKER, *J. Chem. Soc.* (London), (1927) 202.
[x] M. C. KARUNAIRATAN AND G. A. LEVVY, *Biochem. J.*, 44 (1949) 599;
L. M. H. KERR AND G. A. LEVVY, *Biochem. J.*, 48 (1951) 209.
[y] V. T. BOWEN, *J. Exptl. Zool.*, 118 (1951) 509.
[z] C. NEUBERG, *Biochem. Z.*, 76 (1916) 107; *Rev. da Faculdade de Ciéncias de Lisboa*, [2] B. 1 (1952) 165;
H. B. KLEVENS, *Chem. Rev.*, 47 (1950) 63;
O. FLIEG, *Z. Pflanzenernährung, Düngung u. Bodenkunde*, 38, Heft 4 (1935).

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