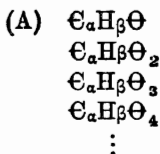


ART. X.—*On the Classification of Organic Substances by Series*;  
by JAMES SCHIEL, of St. Louis.

THE progressive series which in 1842\* I introduced into organic chemistry, have become the chief means of classification and of connecting organic substances generally. Several years after the introduction of the series, Gerhardt used them in the sense just mentioned in his *Traité de Chimie* and thereby contributed a great deal toward their general knowledge.† But the idea this distinguished chemist had formed of series was very imperfect, as is proved by the single fact that he ranged benzoic acid and acetic acid in what he called an isologous series (*Traité*, T. I, 127). As in the present state of chemical science, it is highly important that the principles of seriation be clearly understood, I will try to expound them in a more general and methodical manner than has been done hitherto.

The general formula of organic compounds containing carbon, hydrogen and oxygen is  $C_{\alpha}H_{\beta}O_{\gamma}$ . By giving to  $\gamma$  successively the values 1, 2, 3, 4, ... we may form the following series of oxydation:



From this all the series necessary for the classification of organic substances may be derived by putting  $\alpha=n$  and  $\beta=2n+2$ , making  $\beta$  successively to decrease, the decrement being 2, 4, 6, 8,

\* Annal. Liebig and Wöhler, July number, 1842.

† Gerhardt changed the name progressive into homologous, in the discovery itself of the series he has no share.

... By this we have the following series:

I. $C_n H_{2n+2} \Theta$	II. $C_n H_{2n} \Theta$	III. $C_n H_{2n-2} \Theta$	IV. $C_n H_{2n-4} \Theta$
$C_n H_{2n+2} \Theta_2$	$C_n H_{2n} \Theta_2$	$C_n H_{2n-2} \Theta_2$	$C_n H_{2n-4} \Theta_2$
$C_n H_{2n+2} \Theta_3$	$C_n H_{2n} \Theta_3$	$C_n H_{2n-2} \Theta_3$	$C_n H_{2n-4} \Theta_3$
$\vdots$	$\vdots$	$\vdots$	$\vdots$

and so forth.

Every general formula in one of these generic series represents special homologous series the members of which have the difference  $n \in H_2$ . When comparing the above series with the hydrocarburets known to exist in a free state, they will be found to represent different states of oxydation of these hydrocarburets.

Another kind of series is formed by making in the general formula  $\alpha=n$  and  $\beta=n$  and making  $\beta$  successively to decrease or increase, the increment or decrement being 1, 2, 3, 4, .... By this we form the series:

$$(B.) \begin{array}{l} C_n H_n \Theta_\gamma \\ C_n H_{n+1} \Theta_\gamma \\ C_n H_{n+2} \Theta_\gamma \\ C_n H_{n+3} \Theta_\gamma \\ \vdots \end{array}$$

Every general formula here represents a series, the members of which are distinguished by  $m \in H$  and which I therefore call *hemilogous* series. It is to be remarked that a hemilogous series whose general formula is  $C_n H_{n+1} \Theta_\gamma$ , can only exist when  $n$  is an odd number, as the number of atoms of hydrogen entering into an organic compound is always an even number.\* The hemilogous series are very useful for comparing the physical properties of organic substances.

I will now apply these principles of classification to three large classes or groups of substances, the hydrocarburets, the alcohols and the acids. The generic series formed by the first of these groups is the following:

$C_n H_{2n+2}$  hydrurets of the radicals of the alcohols;  
 $C_n H_{2n}$  the homologues of ethylen and the radicals of the alcohols;  
 $C_n H_{2n-2}$  acetylen  $n=2$ ; allyl  $n=6$ ;  
 $C_n H_{2n-4}$  thymen  $n=10$ ;  
 $C_n H_{2n-6}$  benzol  $n=6$ , toluol  $n=7$ , xylol  $n=8$ , cumol  $n=9$ , cymol  $n=10$ .  
 $\vdots$   
 $C_n H_{2n-1}$  stilben  $n=14$ ;  
 $C_n H_{2n-20}$  hydrocarburet found in the tar of Archangel  $n=19$ .

The maximum or minimum number of atoms of hydrogen which may be combined with  $n$  atoms of carbon cannot be deter-

\* If one atom of nitrogen enters into the compound the atoms of hydrogen are an odd number, as nitrogen is triatomic. For this reason alone the formula of Quinine for instance, could not be written  $C_{10} H_{12} N \Theta$ , as chemists formerly used to do, but  $C_{20} H_{24} N_2 \Theta_2$  as it is written now for other reasons.



$C_7H_8O$  benzoic alcohol, boil. point,  $204^\circ$ .

$C_9H_{10}O$  cinnamic " " "  $250^\circ$ .

the difference in composition is here  $2CH$ , the difference in boiling point,  $46^\circ$ ; to the difference  $CH$  in composition there corresponds therefore a difference in the boiling points of  $23^\circ$ , and as to the difference  $CH_2$ , we mostly find a difference of  $19^\circ-20^\circ$  in boiling points, the influence of the atom of  $H$  on the boiling point is in this case  $3^\circ$ . In a similar manner the influence of  $C$  on the boiling point may be shown to be  $26^\circ$ , as benzoic alcohol and cinnamic alcohol differ by  $C+CH_2$  and  $CH_2$  answers to  $20^\circ$ , we have  $46^\circ-20^\circ=26^\circ$ . The influence of the single elements on the boiling point may thus be found by seriation and general laws deduced by comparing the different results obtained by this method. The acids form quite a number of generic series.

*Series of Acids I.*

$C_nH_{2n}O_2$  fatty acids  $n=1$  to  $n=30$ .

$C_nH_{2n}O_3$  glycolic acid  $n=2$ .

$C_nH_{2n}O_4$  glyceric acid  $n=3$  (isomeric with lactic acid.)

⋮

The acids of this generic series correspond to the first alcoholic series.

*Series of Acids II.*

$C_nH_{2n-2}O_2$

$C_nH_{2n-2}O_3$

$C_nH_{2n-2}O_4$

$C_nH_{2n-2}O_5$

⋮

The special homologous series deriving from this generic series are,

$C_3H_4O_2$  acrylic acid.

$C_2H_2O_3$  glyoxylic acid.

$C_4H_6O_2$  crotonic "

$C_3H_4O_4$  pyroracemic acid.

$C_5H_8O_2$  angelic "

⋮

etc. etc.

—

$C_2H_2O_4$  oxalic acid.

$C_3H_4O_5$  tartronic acid.

$C_3H_4O_4$  malonic "

$C_4H_6O_5$  malic "

$C_4H_6O_4$  succinic "

⋮

$C_5H_8O_4$  lipic "

—

etc. etc.

$C_4H_6O_6$  tartaric acid.

$C_6H_{10}O_8$  mucic acid.

⋮

—

*Series of Acids III.*

$C_nH_{2n-4}O_2$

$C_nH_{2n-4}O_3$

$C_nH_{2n-4}O_4$

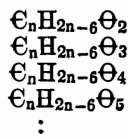
$C_nH_{2n-4}O_5$

⋮

From this generic series are derived :—

$\text{C}_6\text{H}_8\Theta_2$ sorbic acid.	$\text{C}_3\text{H}_2\Theta_5$ mesoxalic acid.
$\text{C}_4\text{H}_4\Theta_4$ maleinic acid.	$\text{C}_6\text{H}_5\Theta_7$ citric acid.
$\text{C}_5\text{H}_6\Theta_4$ itaconic “	
$\text{C}_6\text{H}_8\Theta_4$ ?	
$\text{C}_7\text{H}_{10}\Theta_4$ terebinic “	

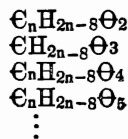
*Acid series IV.*



From this generic series we derive :—

$\text{C}_6\text{H}_6\Theta_2$ oxyphenic acid.	$\text{C}_5\text{H}_4\Theta_3$ pyromucic acid.
$\text{C}_8\text{H}_{10}\Theta_2$ terebentic “	$\text{C}_6\text{H}_6\Theta_3$ pyrogallic “
	$\text{C}_7\text{H}_8\Theta_3$ ipecacuanic “
	$\text{C}_8\text{H}_{10}\Theta_3$ ricinoleic “
$\text{C}_4\text{H}_2\Theta_4$ mellitic acid.	$\text{C}_6\text{H}_5\Theta_5$ aconitic acid.*
$\text{C}_2\text{H}_{10}\Theta_4$ cholesteric “	

*Acid series V.*



From this generic series we derive :—

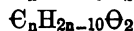
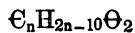
$\text{C}_7\text{H}_6\Theta_2$ benzoic acid.	$\text{C}_5\text{H}_2\Theta_5$ krokonic acid.
$\text{C}_8\text{H}_8\Theta_2$ toluylic “	$\text{C}_6\text{H}_4\Theta_5$ comenic “
$\text{C}_9\text{H}_{10}\Theta_2$ ?	$\text{C}_7\text{H}_6\Theta_5$ gallic “
$\text{C}_{10}\text{H}_{12}\Theta_2$ cuminic “	$\text{C}_{24}\text{H}_{40}\Theta_5$ cholic “
	$\text{C}_7\text{H}_6\Theta_3$ salicylic acid.
$\text{C}_8\text{H}_8\Theta_6$ phenoxacetic acid.	$\text{C}_8\text{H}_8\Theta_3$ anisic “
	$\text{C}_9\text{H}_{10}\Theta_3$ phloretinic acid.

\* The radical of the tribasic aconitic acid  $\text{C}_6''' \text{H}_3 \Theta_3 \left\{ \begin{array}{l} \text{H}_3 \\ \Theta_3 \end{array} \right\}$  may be derived from a hydrocarburet by substitution of  $\text{H}_6$  by  $\Theta_3$ , as acetic acid is formed by substitution of  $\text{H}_2$  by  $\Theta$  in the radical  $\text{C}_2\text{H}_5$ . The triacid alcohol or glycerin corresponding to aconitic acid would therefore be  $\text{C}_6''' \text{H}_9 \left\{ \begin{array}{l} \text{H}_3 \\ \Theta_3 \end{array} \right\}$ ; it belongs to the alcoholic series II, answering to the general formula  $\text{C}_n\text{H}_{2n}\Theta_3$ , and the type  $\text{C}_n''' \text{H}_{2n-3} \left\{ \begin{array}{l} \text{H}_3 \\ \Theta_3 \end{array} \right\}$ . This remark applies, *mutatis mutandis*, to other acids.

$C_8H_8\Theta_4$  lecanoric acid.

$C_9H_{10}\Theta_4$  veratric acid.

*Acid series VI.*

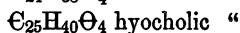
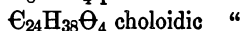
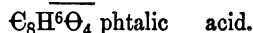


⋮

Of the acids deriving from this generic series only a few are known as yet.

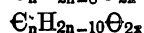
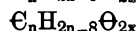
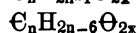
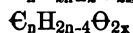
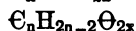
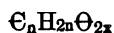
$C_9H_8\Theta_3$  cumaric acid.

$C_7H_4\Theta_7$  mionic acid.



From other known acids it is hardly possible to form series, as they stand mostly isolated; there is for instance only one acid—anemonic acid  $C_{15}H_{14}\Theta_7$ —known as yet, which corresponds with the general formula  $C_nH_{2n-16}\Theta_7$ .

The generic series of acids considered above may be ranged into one primitive series:



⋮

where  $\Theta_x^z$  means, that in order to form a generic series from one of these primitive formulas,  $\Theta$  has successively to receive suffixed the numbers 2, 3, 4, . . .  $x$ . It is easy to see that as every generic series, as for instance:



⋮

consists of two kinds of series, of which those lying on the horizontal lines are homologous series, and those lying on the vertical lines are series of oxydation, the primitive series therefore expresses a *seriation in a cube*.

It is worth observing that there may be series of isomeric substances running parallel to each other; such series may be called *homarithmical series*.