THE SYSTEMIC APPROACH TO TEACHING AND LEARNING HETEROCYCLIC CHEMISTRY [SATLHC]: OPERATIONAL STEPS FOR BUILDING TEACHING UNITS IN HETEROCYCLIC CHEMISTRY

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ABSTRACT

This paper focuses on the uses of systemic approach to teaching and learning in heterocyclic chemistry [SATLHC]. This work first presents the general strategy of converting linear traditional unites into systemic unites. Then it makes use of this general strategy in building unite of five-member heterocyclic compounds namely Pyrrole, Furan and Thiophene. The scenario of teaching the parts of this unite is also presented. This unite was presented as applicable model to convert linear unites to systemic unites in heterocyclic chemistry. *[AJCE, 3(2), June 2013]*

INTRODUCTION

After the wide spread use of systematization in various activities including, tourism, economy, security, education, etc, and after globalization became a reality that we live, SATL became a must and Chemical Education Reform (CER) has gained great importance internationally. SATL is a new way of teaching and learning, based on the idea that nowadays everything is related to everything globally. Students shouldn't learn isolated facts (by heart), but they should be able to connect concepts and facts in an internally logical context.

Taagepera and Noori (1) tracked the development of student’s conceptual understanding of organic chemistry during a one-year sophomore course. They found that the student’s knowledge base increased as expected, but their cognitive organization of the knowledge was surprisingly weak. The authors concluded that instructors should spend more time making effective connections, helping students to construct a knowledge space based on general principles. Pungente, and Badger (2) stated that the primary goal of teaching introductory organic chemistry is to take students beyond the simple cognitive levels of knowledge and comprehension using synthesis and analysis – rather than rote memory.

Fahmy and Lagowski (3) suggested an educational process based on the application of “Systemics” named (SATL). The use of systemics can help students begin to understand interrelationships of concepts in a greater context, a point of view, once achieved, that ultimately should prove beneficial to the future citizens of a world that is becoming increasingly globalized. Moreover, if students learn the basis of the systemic process in the context of learning chemistry, we believe that they will doubly benefit by learning chemistry and learning to see all subjects in a greater context (4-6). SATL-in Heterocyclic Chemistry was experimented successfully on the third year major chemistry students at Ain Shams University (7-8).

What is the meaning of SATL?

By SATL it is meant an arrangement of concepts or issues through interacting systems in which all relationships between concepts and issues are made clear up front to the teacher and learner (5) as in figure 1 below.

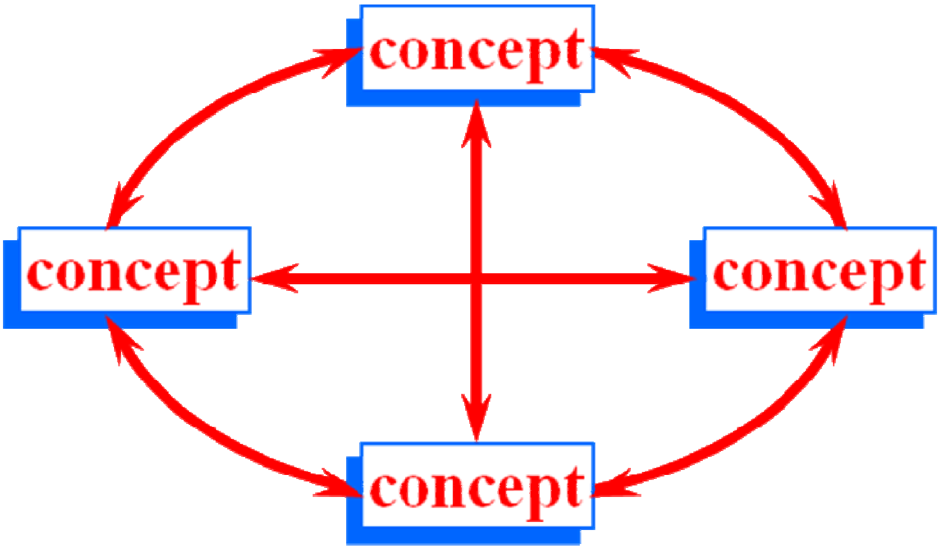


Figure 1: Concepts in SATL

Systemic teaching strategy: [STS]

We started teaching any unit by Systemic diagram (SD0) that has determined the starting point of the unit, and we ended with a final systemic diagram (SDf) and between both we crossover several Systemics (5).

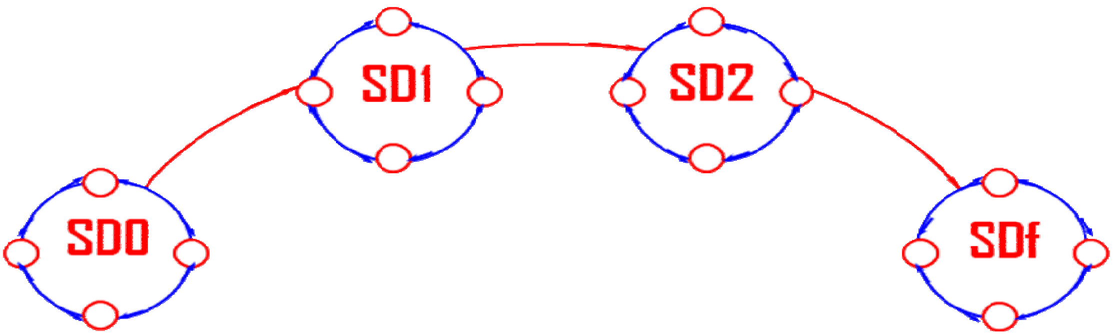


Fig (2): Systemic teaching strategy

The systemic diagrams involved in teaching are similar except that the number of known relationships (√) and the unknown (?) ones as indicated in the Fig.2. A list of SATLC materials were produced in Egypt, for instance, SATL General Chemistry for secondary schools, SATL Aliphatic, Aromatic, Green chemistry and Heterocyclic Chemistry for University Level. In this paper, systemic heterocyclic chemistry teaching materials will be illustrated.

USES OF SATL-IN BUILDING UNITES: [GENERAL BUILDING STRATEGY]

In SATL building strategy of unites, we convert the linearly based unites in chemistry to systemically-based unites according to the following general building strategy (9):

First: The systemic aims and the operational objectives for the unit should be defined in the frame of national standards.

Second: The prerequisites needed for teaching the unit from previous studies (concepts, facts, laws, reaction types and skills) should be tabulated in a list.

Third: Then content analysis of the linearly-based units into concepts, facts, laws, reaction types, mental and experimental skills.

Fourth: Draw a diagram illustrating linear relations among the concepts of the unit (figure 3).

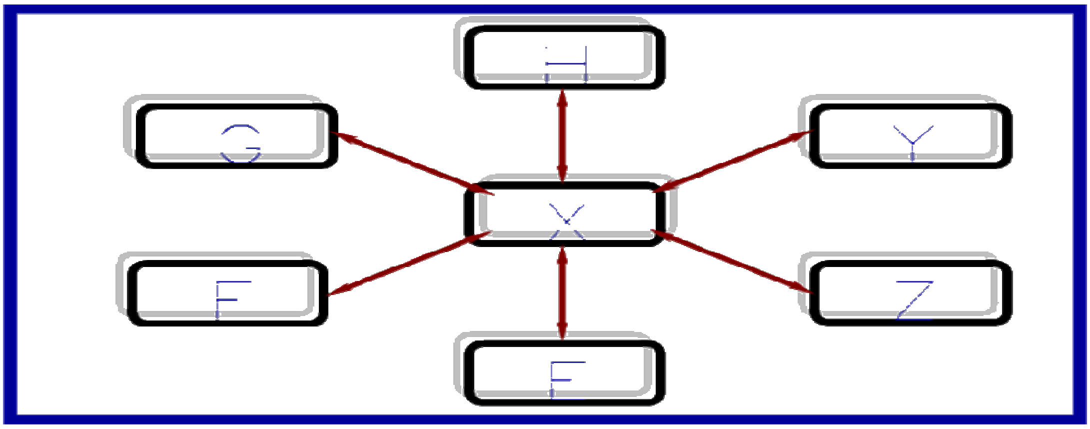


Fig. (3): Linear relations between concepts of the unit

<u>Fifth:</u> We put the sign (√) on the already <u>known</u> relationships between concepts from previous studies. Then the remaining linear relations are <u>unknown</u> and signed by (?). So, the diagram in Fig-3 should be modified as shown in Fig. 4.

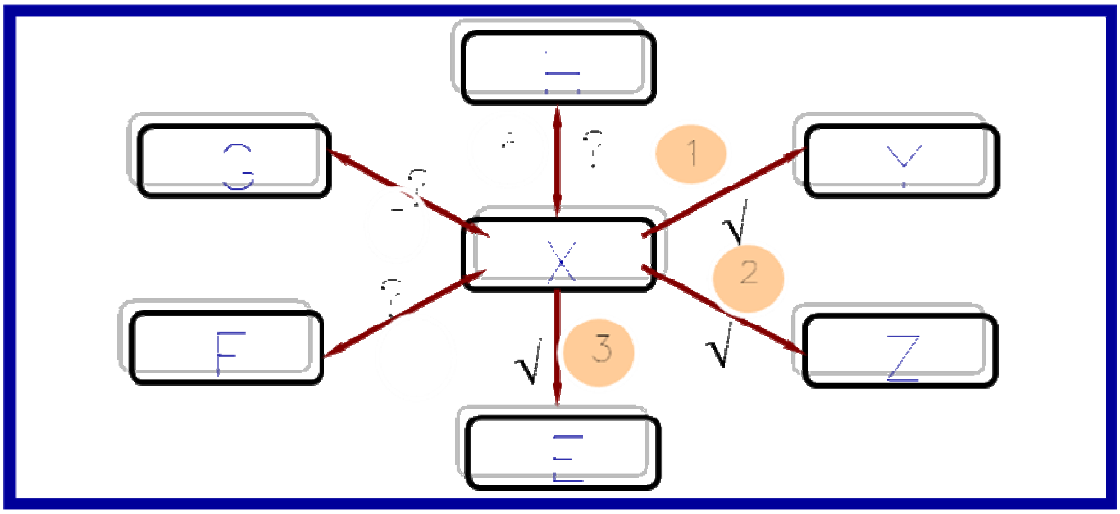


Fig (4): Linear relations between concepts after defining the known from the unknown

<u>Sixth</u>: The diagram in Fig.4 is modified to a systemic diagram SD0 as in Fig.5 by adding unknown relations between the concepts from 7 to 12. SD0 is known as the starting point of teaching the unit.

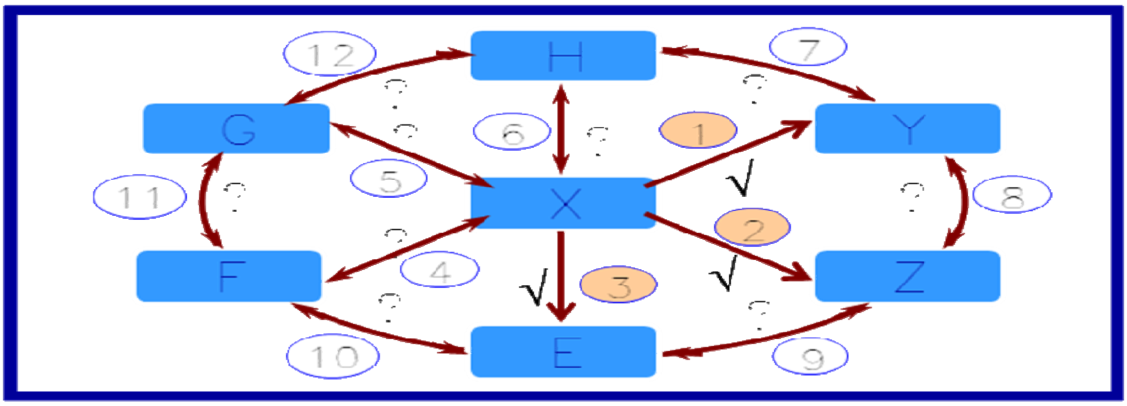


Fig (5): SD0 the starting point for teaching the unit

SD0 shows the systemic relations between concepts after defining the known from the unknown.

Seventh: In the scenario for teaching the unit, the student studies the relations 7, 8 and 9. So, he/she will be able to add them to SD0 diagram to give SD1 diagram as in Fig.6.

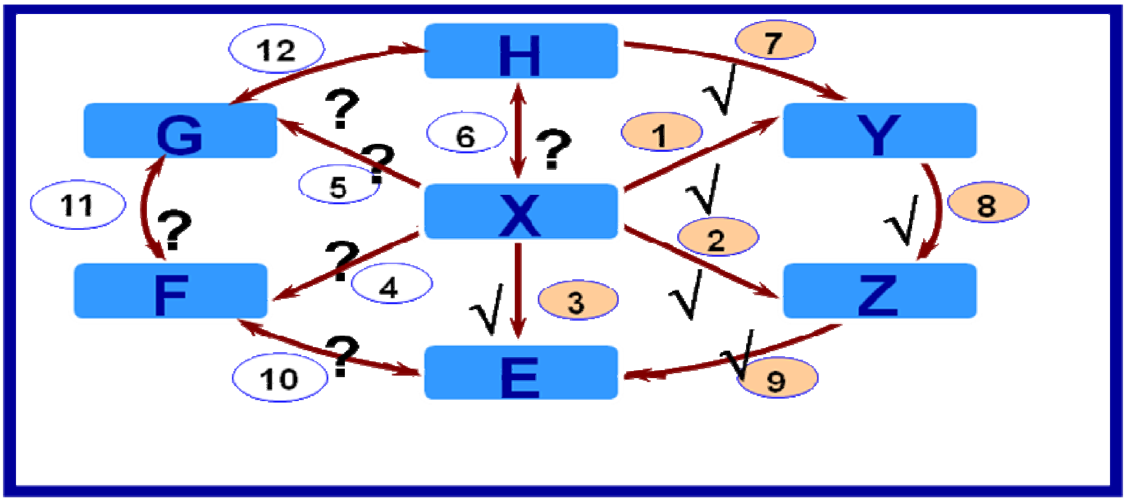


Fig. (6): [SD1

At this stage of teaching the unit we can ask the students to build systemics showing the relations between the concepts (X, Y, Z, and E) via systemic assessment.

Eighth: In the next stage of the scenario of teaching the unit, the student studies the relations 4, 5, 10, and 11 and then he/she will be able to add them to SD1 to obtain SD2- Fig.7.

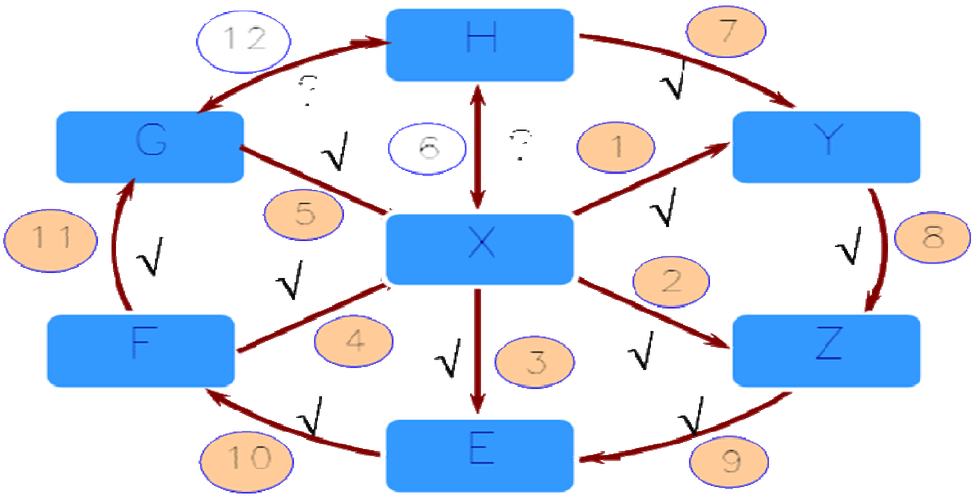


Fig. (7): SD2

Ninth: In the last stage of teaching the unit, the student studies the two relations, that is 6 and 12. Then he/she adds them to SD2 to obtain SD3-Fig.8 where we reached to the end of the systemic teaching of the unit.

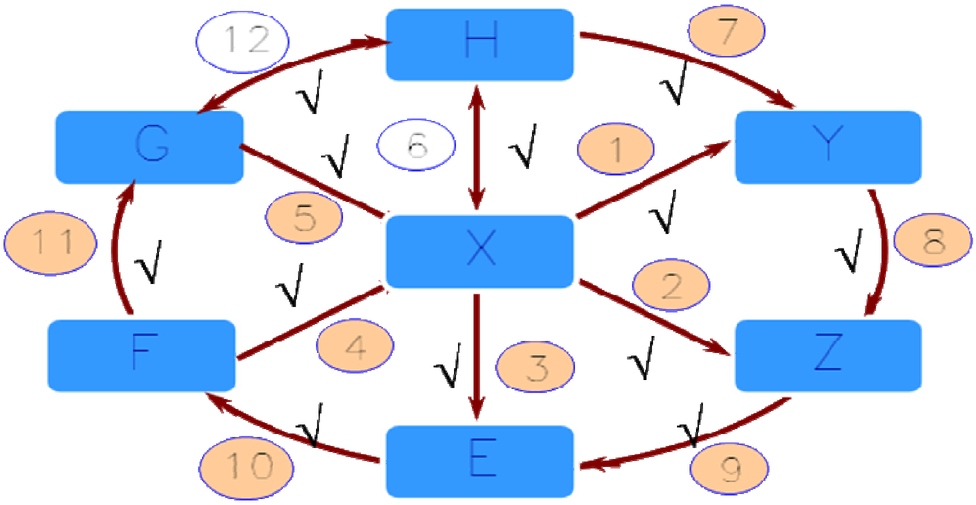


Fig. (8): SD3

SD3 can be denoted as the terminal systemic SDf of the unit.

Tenth: The scenario of teaching any course systemically involves the development of a systemic diagram (SD0) that has determined the starting point of the course; it incorporates the prerequisite materials.

The course ends with a terminal systemic (SDf) in which all the relationships between concepts are known (Fig. 8). In going from SD0 through SDf we crossover several systemics with known and unknown relationships like SD1, SD2, etc. (9).

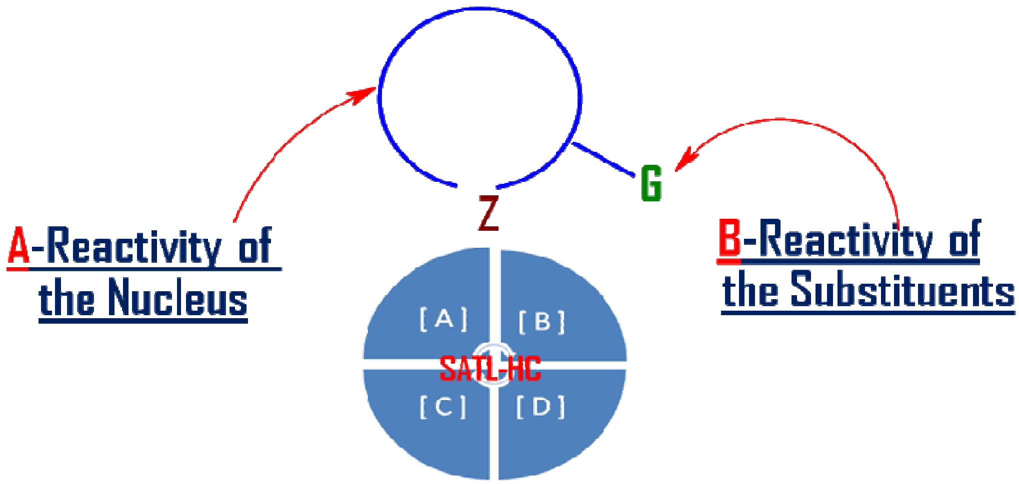
There are some difficulties in learning heterocyclic chemistry (HC) by traditional methods. The students find the following difficulties in learning HC:

- To remember the structural formulas of heterocycles and chemical properties related to these structures

- To understand the systemic effect of heteroatom on the reactivity of both heterocycles and their substituent
- To synthesize systemic chemical relations between compounds of the same or different heterocycles
- To understand the importance of heterocycles in their life's
- To design synthesis of new target heterocycles via RSA
- To connect between different heterocyclic systems

USES OF SATL-IN BUILDING UNITES IN HETEROCYCLIC CHEMISTRY: [A**PPLICATION OF SYSTEMIC BUILDING STRATEGY IN HC]**

A course of heterocyclic chemistry using the SATL technique (8) was organized and taught to the 3rd year students at Ain Shams University. SATLHC means a survey study on the reactivity of both heterocycles and their substituents and the effect of heteroatom on their possible chemical relations.



C-Heteroatom: [(Z) = NH, O, S]

D-Substituents:[(G) = R, - CH_2 - X, - X, -CH_2 - OH - NH_2, - CHO, - COR, - COOH]

Scenario of Building Units on 5-Membered Heterocycles

We can apply the steps of general systemic building strategy (9) to build the unit of 5-membered ring as follows:

First: Draw a diagram that summarizes linear comparative reactivities of the 5-membered heterocycles as a model of heterocyclic compounds, and their possible chemical relations like in figure 9.

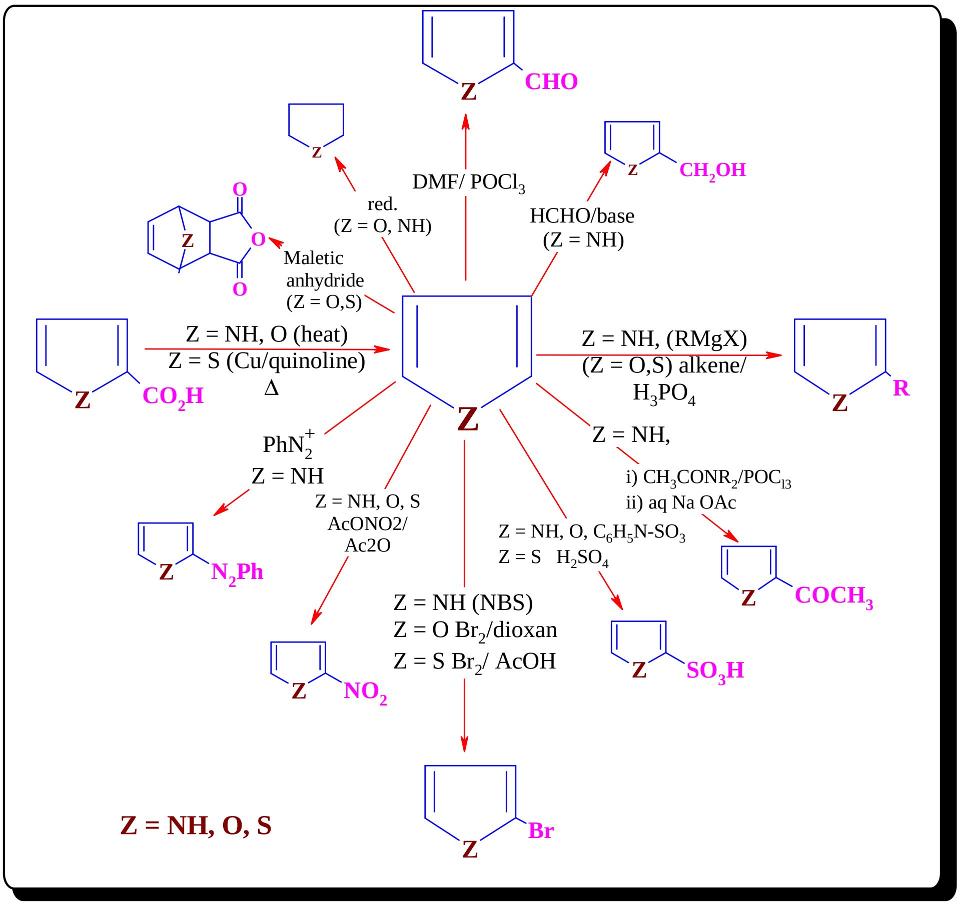


Fig 9: Linear comparative reactivities of the 5-membered heterocycles

The diagram in fig.ure 9 represents the comparative reactivities of 5-membered heterocyclic rings, and gives the linear separated chemical relations among Pyrrole, Furan, and Thiophene, and their compounds.

Second: The diagram in figure 9 is modified to a systemic diagram SD1 (Fig.10) by adding relations between heterocyclic derivatives. SD1 summarizes the comparative reactivities of both heterocyclic nucleus and substituents.

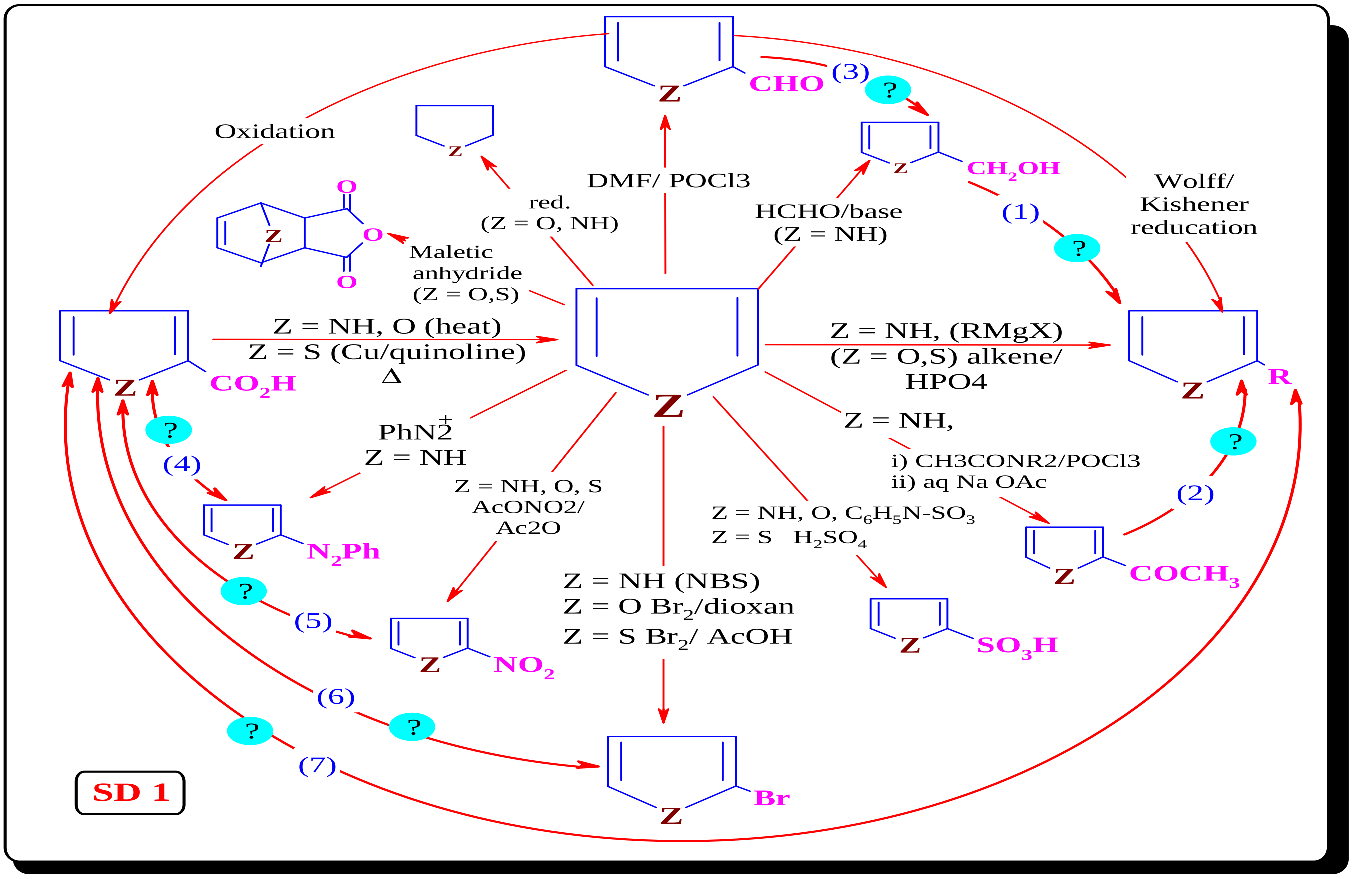


Figure 10: SD1

The systemic diagram SD1 shows unknown chemical relations 1 through to 7 between heterocyclic compounds. These relations will be clarified later during the study of the unit [pyrrole, furan and thiophen].

Reactions of Pyrrole, Furan, Thiophene and Their Compounds

I-Pyrrole: (Prerequisites SD1):

Third: From Fig.9 the student can deduce the reactions of pyrrole as in the following diagram (Fig. 11) by changing [Z=NH].

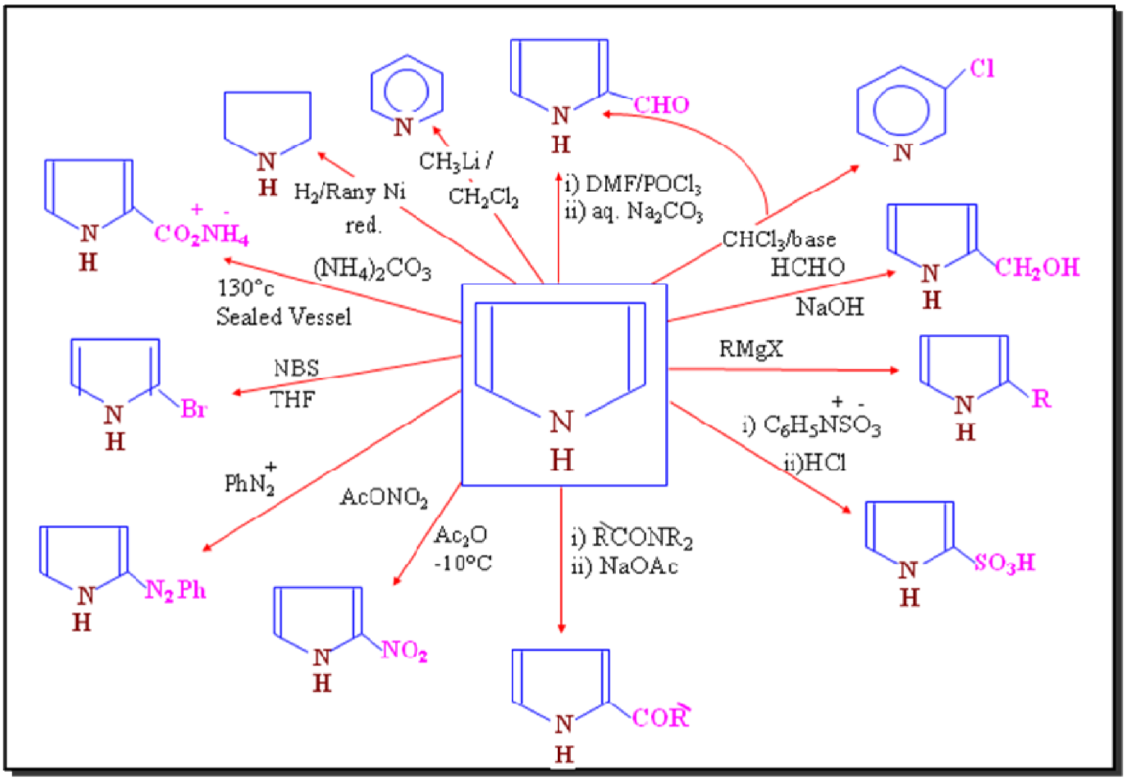


Figure 11: Reactivity of pyrrole nucleus

The diagram (Fig. 11) represents the reactivity of pyrrole nucleus and gives the linear separated chemical relations between pyrrole and its compounds.

Fourth: The student can illustrate the chemical relations in Fig.11 systemically by modification of SD1 to SD2 (Fig.12) (**Z = NH**).

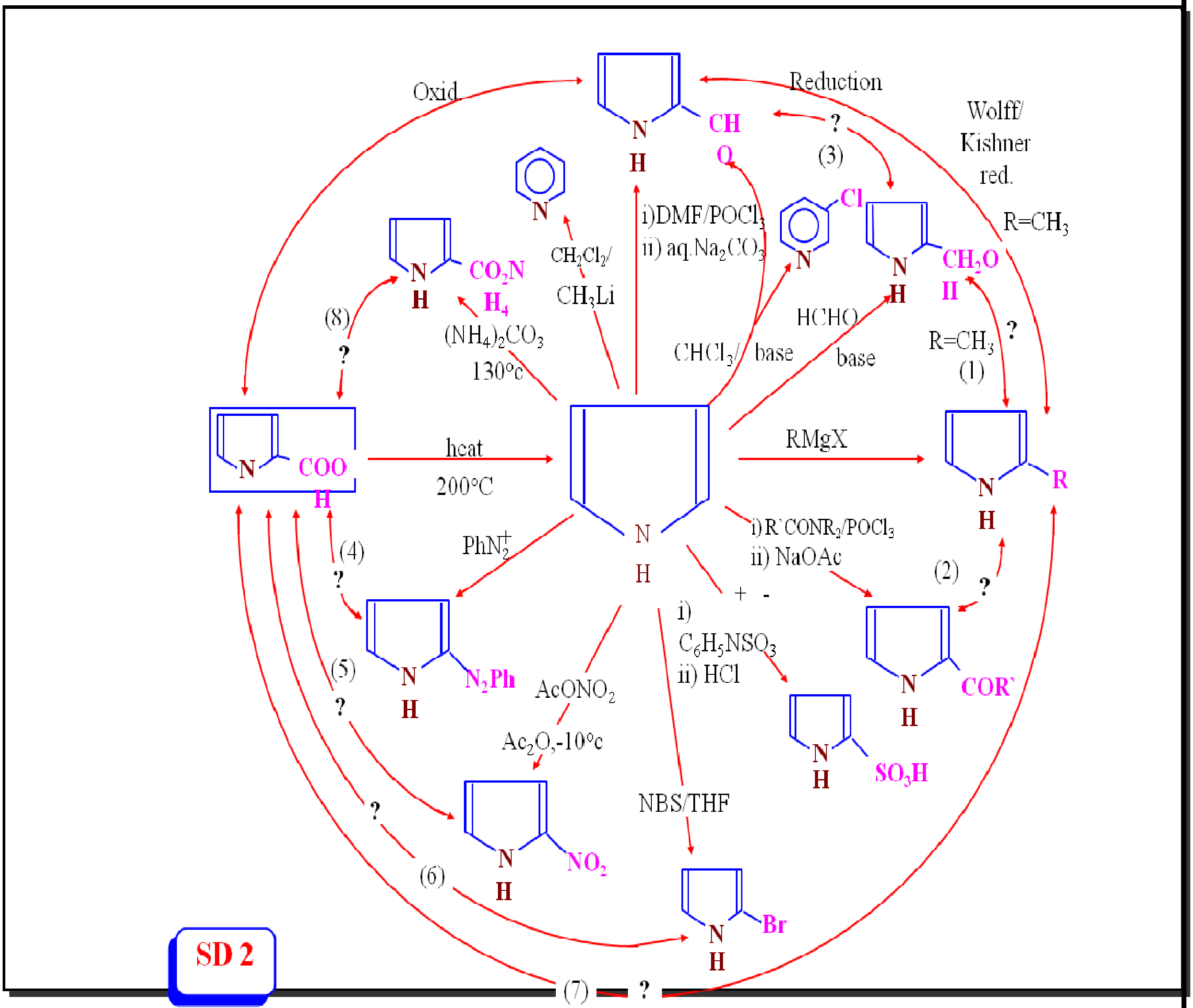
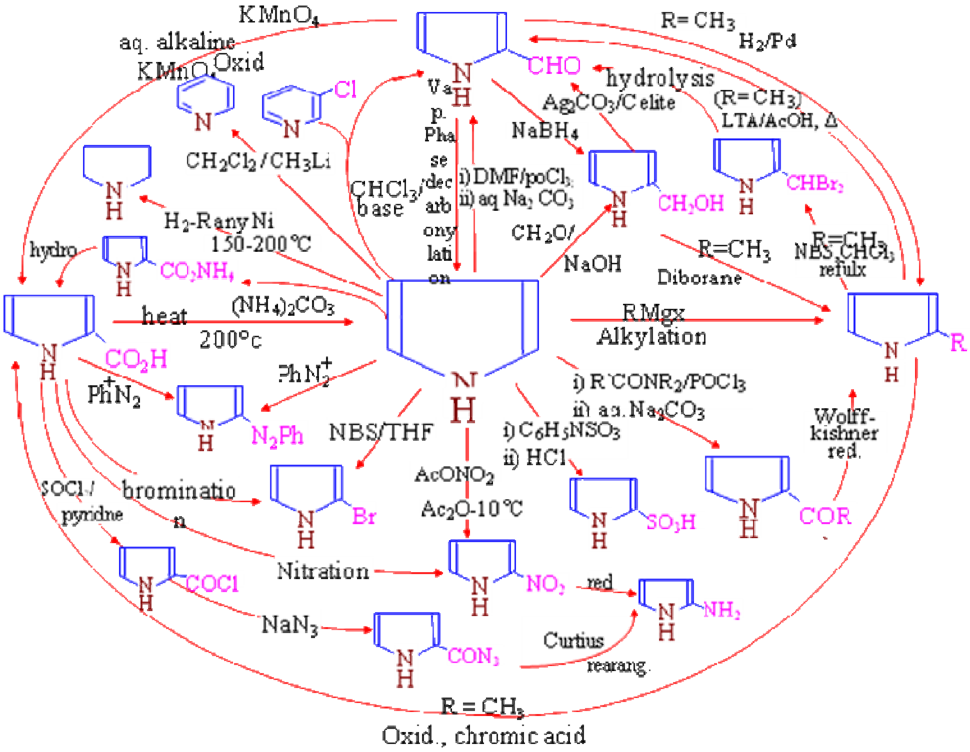


Figure 12: SD2

Systemic diagram (SD2) shows

- known chemical relations between pyrrole and its compounds
- Unknown chemical relations between pyrrole compounds of 1 through 8 that should be clarified during the study of pyrrole compounds.

Fifth: After study of pyrrole compounds [G = R, CH_2OH, CHO, RCO, COOH, and NH2) the student can modify (SD 2 to SD 3) like in figure 13 by adding chemical relations 1 through 8.



SD 3

Figure 13: SD3

In the systemic diagram (SD3) all the chemical relations between Pyrrole compounds are clarified as in 8 and10. At this stage of teaching the unit we can stop and ask the students to answer Systemic Assessment Questions [SAQ, s] to assess students' achievements on Pyrrole chemistry (11).

II-Furan: Prerequisite SD1

Sixth: From Fig.9 the student can illustrate all the reactions of furan [**Z=O**] as in Fig.14.

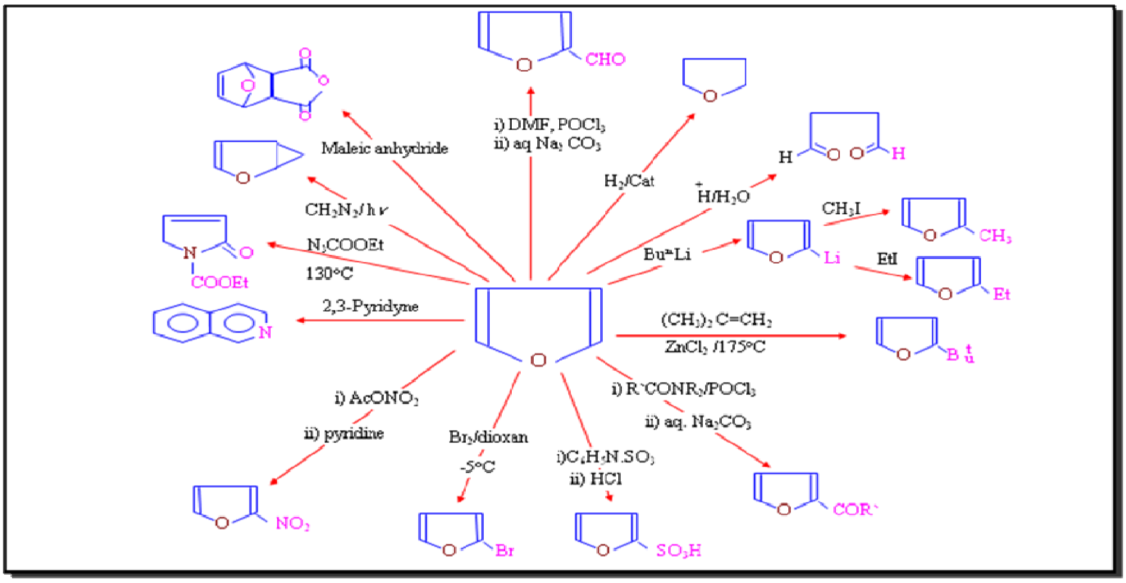


Figure 14: Reactivity of furan nucleus that gives the linear separated chemical relations between furan and its compounds

Seventh: From SD1 the student can illustrate the systemic chemical relations of furan in (Fig. 15) by modifying (SD1 to SD4) [Z=O]

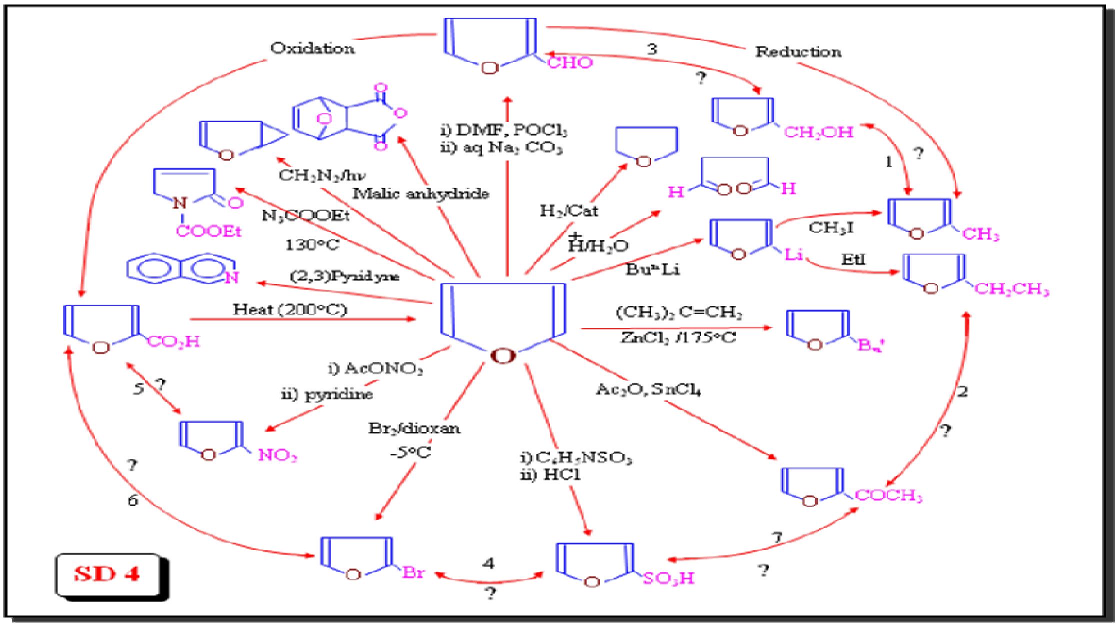


Figure 15: SD4

The systemic diagram SD4 shows

(i) Known chemical relation between furan and its compounds

(ii) Unknown chemical relations between furan compounds as in 1 through 7

Eighth: After the next stage of the study of furan compounds [G = R, X, CH2OH, CHO, RCO, COOH] the student can modify (SD4 to SD5) like in figure 16 by additions chemical relations 1 through 7.

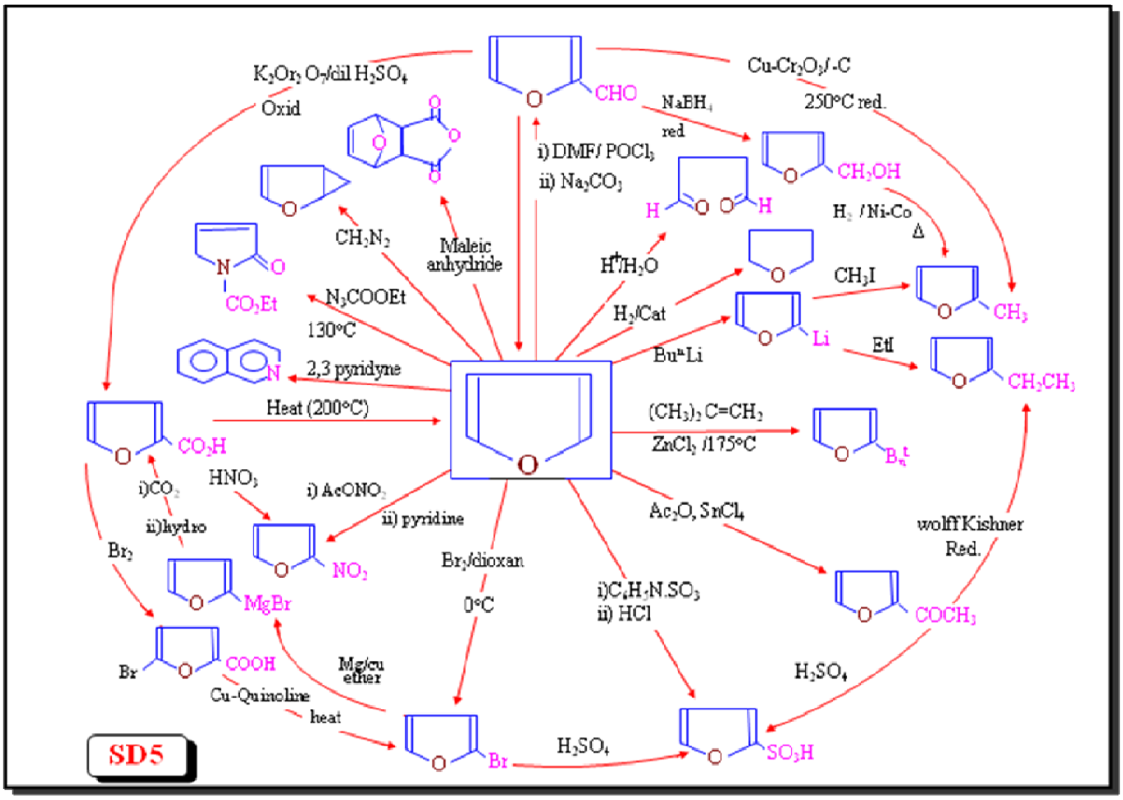


Figure 16: SD5

In the systemic diagram SD5 the chemical relations between furan compounds are clarified like 8 and 10. At this stage of teaching the unite we can stop and ask the students to answer Systemic Assessment Questions [SAQ,s] to assess students achievements on Furan chemistry (11).

III-Thiophene: *(*Prerequisite SD1)

Ninth: From Fig.9 the student can summarize all the reactions of thiophene in the following diagram (Fig. 17). [Z=S]

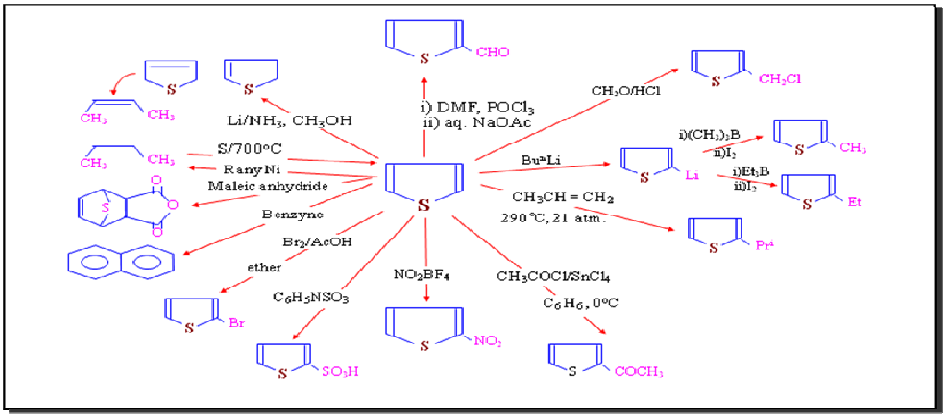


Figure 17: The reactivity of thiophene nucleus that gives the linear separated chemical relations between thiophene and thiophene compounds

Tenth*:* The student can illustrate the chemical relations in (Fig. 18) systemically by modifying (SD1 to SD6) [Z = S].

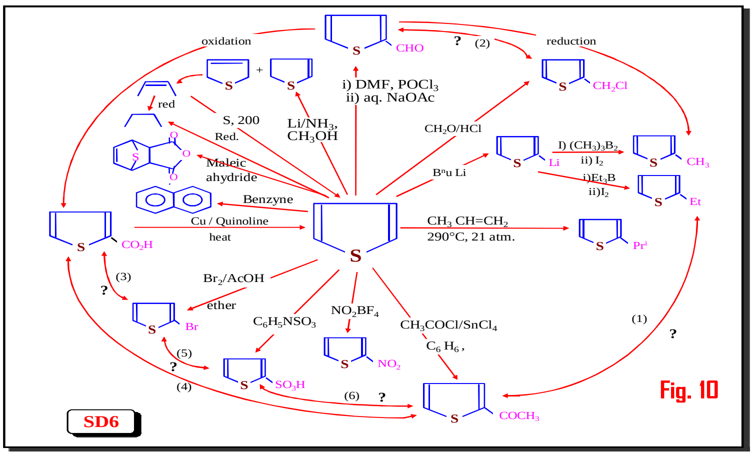


Figure 18: SD6

The above systemic diagram (SD 6) shows

(i) The known chemical relations between thiophene and its compounds

(ii) The unknown chemical relations between thiophene compounds 1 through 6.

Eleventh: After the next stage of the study of Thiophene compounds [G = R, X, CH_2OH, CHO, RCO, COOH] the student can modify (SD6 to SD7) as in figure 19 by addition of chemical relations 1 through 6.

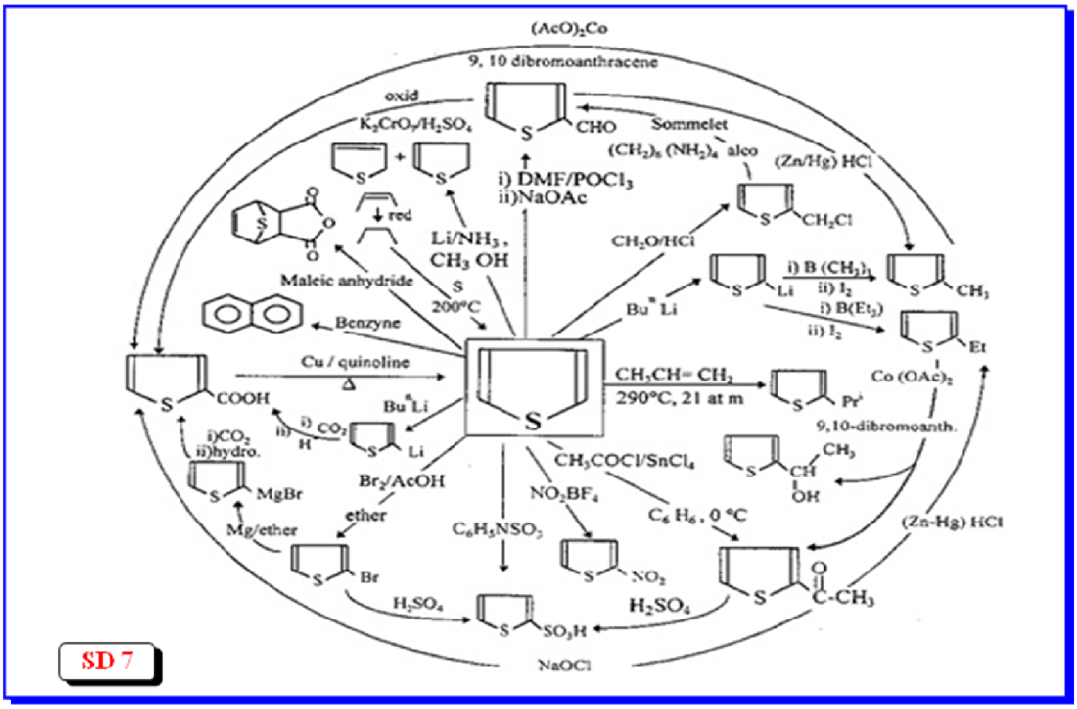


Figure 19: SD7

In the (SD7) all chemical relations between thiophen compounds were clarified as 8 and 10. At this stage of teaching the unit we can stop and ask the Students to answer Systemic Assessment Questions [SAQ,s] to assess students' achievements on Thiophene chemistry (11). At this stage we reach to the end of the unit.

CONCLUSIONS

After the experimentation of SATLHC in Egypt we reached to the following conclusions (7-8):

- ♦ SATLHC improved the students' ability to view HC from a more global perspective.
- ♦ SATLHC increases students' ability to learn subject matter in a greater context.
- ♦ SATLHC helps the students to develop their own mental framework at higher-level cognitive processes (application, analysis, and synthesis).

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