# MINDO/3 EVALUATION OF OXIDATION NUMBERS IN SOME TRISUBTITUTED BENZENS

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**Oxidation numbers of atoms in the molecule have been calculated by semi-empirical bond order matrix using Giambiagi's definition, with all valence basis sets for some trisubstituted benzens wit- OH, -$NH_2$ and -$CH_3$ as substituents. The present study suggests that the oxidation numbers seem to be indicative of their orientational behaviour like net atomic charges.**

## INTRODUCTION

A useful concept for describing and interpreting the extent of electron transfer to or from the vicinity of a given nucleus in a molecular environment and during the course of a chemical reaction, is the oxidation number. Unfortunately, no reliable theory is yet available for direct evaluation of the oxidation number and only qualitative quantum chemical approaches, based on population analysis (1955) or electron density distribution (Bader 1989; collins and Streitwiser 1980; Hilal 1980), which, however, is not suitable for obtaining system and accurate results within a limited computer time. On the other hand, Giambiagi et.al. (1984) have defined oxidation numbers in terms of bond order indices and this definition leads to dramatic changes in the oxidation numbers as happens classically. Keeping in mind the above facts, it was thought worth to apply Giambiagi's method to some trisubstituted benzens with -OH, -$NH_2$ and -$CH_3$ as substituents at positions -1,2,4. A calculation on the similar lines has already been presented by Tripathi et.al. (1998) for trisubstituted benzens with these substituents at positions -1,2,3.

## METHOD OF CALCULATIONS

Giambiagi et.al. (1984), suggested the definition of oxidation number $\Xi_A$ of an atom A in a molecule as

$$\Xi_A = [\,|Q_A|/Q_A]\sum_{A \neq B} B_{AB} \quad \text{.....................(I)}$$

Where $Q_A$ is net the atomic charge in A and the sum is carried over the atoms with polarity different from that of atom A and

$$Q_A = N_A - q_A \quad \text{.........................(2)}$$

and

$$q_A = \sum_{aEA} q_a \quad \text{..........................(3)}$$

Where $N_A$ is the number of valence electrons which atom A furnishes to the molecule and the second terms in equation (2) is the electronic charge in A defined by equation (3). This sum is carried out over all the atomic orbitals electronic charges of atom A. $B_{AB}$ is the bond order index between atoms A and B defined by

$$B_{AB} = \sum_{a}^{A} \sum_{b}^{B} P_{ab}^{2} \qquad \text{.......................(4)}$$

Where a and b are the atomic orbitals related to atoms A and B respectively and $P_{ab}$ are the elements of the diatomic part of the bond order matrix. A complete MIDNO/3 compute program obtained from Quantum Chemistry Program Exchange (Q.C.P.E.-U.S.A.) was extended to incorporate the suggestions of Giambiagi et.al. (1984). The signs of the oxidation numbers of different atoms are obtained from the signs of the net atomic charges (not reported in the table in order to save the space) of the respective atoms. Except for the molecule containing- $CH_3$ group, all molecules were taken to be planar with the benzene ring angles 120° (ring a regular hexagon). The geometry of the benzene ring is assumed to be unaffected by the substitution. The successive substituents ground state geometry has been taken from the Landolt-Borestin table (structure data of free polyatomic molecules, 1976). The C-C (ring), C-O (-OH), C-N (-$NH_2$), C-C (-$CH_3$), C-H, N-H, O-H and C-H (-$CH_3$) bond length have been taken 1.397, 1.380, 1.420, 1.540, 1.084, 1.040, 0.940, and 1.100 A° respectively. The angels H-N-H, H-O-C, and C-C-H in $NH_2$, OH-, and $CH_3$- substituted molecules respectively are taken to 107, 105 and 109.5°.

## RESULTS AND DISCUSSIONS

The calculated oxidation numbers have been presented in table-1. This defination, appropriate for neutral species, ensures that oxidation numbers in a molecule add upto zero. A close inspection of this table indicates that the fractional values obtained in our calculations are equal (at least close) to the integers predicted in classical approaches. A set of signed (positive or negative) values are assigned to individual atoms so that their sum equals to the total charge on the molecule. The carbon atoms attached to the substituents acquire positive values while other carbon atoms are observed to show negative values in all the molecules of the present study except in -$CH_3$ substituted benzene. The hydrogen atoms in the -OH and -$NH_2$ groups, have some what smaller values of oxidation numbers as compared to ring hydrogens. The oxidation numbers of the oxygen atoms are found to have values very close to its valence index. This is because the oxygen atom has a polarity different from that of other two atoms (i.e. H (-OH) and C) attached to it and thus its valence coincides with the oxidation number. Similar results hold good for the other substituent atoms, namely nitrogen and carbon in the -$NH_2$ and $CH_3$ groups, respectively. Due to the negative oxidation numbers of the substituent atoms, the ring is left with a positive charge as a whole, which in turn discourages any further electrophilic substitution.

## CONCLUSION

Besides various well-known properties of the oxidation number, viz in enabling one to tell whether a substance taking part in a chemical reaction is oxidized or reduced; in the balancing of chemical equation, and in calculation of the equivalent weights of oxidizing and reducing agents etc. the oxidation number, like the net charges may be used as reactivity index upto some extent. However, in general, the present study confirms the validity of the statement of Cotton and Wilkinson (1979). Since the only thing that is physically and chemically important is the actual electron distribution. it seems that in essentially covalent bonding situation, ionic formulations with their attendant necessity for, or consequence of, assigning oxidation numbers are best avoided.

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## ANNEX

Table-1: Oxidation Numbers of the Atoms in Some Molecules

| 1,2,4 Trihydroxy Benzene | | 1,2,4 Triamino Benzene | | 1,2,4 Trimethy 1 Benzene | |
|---|---|---|---|---|---|
| Atoms | Oxidation Nos | Atoms | Oxidation Nos | Atoms | Oxidation Nos |
| $C_1$ | +2.4005 | $C_1$ | +1.0885 | $C_1$ | +0.0976 |
| $C_2$ | +2.4727 | $C_2$ | +2.4995 | $C_2$ | +1.5585 |
| $C_3$ | -3.6727 | $C_3$ | -3.7507 | $C_3$ | -2.9167 |
| $C_4$ | -3.6600 | $C_4$ | +3.7033 | $C_4$ | +2.8246 |
| $C_5$ | -2.4597 | $C_5$ | -3.8061 | $C_5$ | -2.9183 |
| $C_6$ | -2.3696 | $C_6$ | -1.5470 | $C_6$ | +2.4889 |
| $C_7$ | -1.8907 | $N_7$ | -3.0218 | $C_7$ | +2.9079 |
| $O_8$ | -1.9126 | $N_8$ | -2.9896 | $C_8$ | +2.8983 |
| $O_9$ | +0.9583 | $H_9$ | +0.9568 | $H_9$ | -0.0440 |
| $O_{10}$ | -1.8802 | $N_{10}$ | -2.9792 | $C_{10}$ | +2.9100 |
| $H_{11}$ | +0.9697 | $H_{11}$ | +0.9564 | $H_{11}$ | -0.0429 |
| $H_{12}$ | +0.9594 | $H_{12}$ | +0.9850 | $H_{12}$ | -0.9826 |
| $H_{13}$ | +0.9129 | $H_{13}$ | +0.9590 | $H_{13}$ | -0.9805 |
| $H_{14}$ | +0.9173 | $H_{14}$ | +0.9593 | $H_{14}$ | -0.9821 |
| $H_{15}$ | +0.9256 | $H_{15}$ | +0.9415 | $H_{15}$ | -0.9821 |
| | | $H_{16}$ | +0.9781 | $H_{16}$ | -0.9745 |
| | | $H_{17}$ | +0.9693 | $H_{17}$ | -0.9754 |
| | | $H_{18}$ | +0.9689 | $H_{18}$ | -0.9754 |
| | | | | $H_{19}$ | -0.9729 |
| | | | | $H_{20}$ | -0.96.92 |
| | | | | $H_{21}$ | -0.96.92 |

# ENTOMOPATHOGENIC NEMATODES: THE PARASITES USEFUL FOR BIOLOGICAL CONTROL STRATEGY

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## INTRODUCTION

As the animals fall upon categories of consumers in the community, some of them take share of the food grown by the humans and are broadly spoken as the pests. Any group including molluska, insecta, aves and mammalia may have the examples of pests which thus provide tremendous damage to the human economics by harboring the agricultural products right from the field to the store houses. Hence the destruction of the pests populations became a compulsion to the human society so as to feed up its day to day growing population properly.

## EMERGENCE OF PESTICIDES

After an encouraging success of genocide brought about by chemicals in the second world war, man was inspired to use them in his developmental activities, particularly to destruct the pest population and increase agricultural population. As a result several artificial toxic chemicals were started to be released into the environment. This included chlorinated hydrocarbon including DDT, deildrin, aldrin ect. and shortly found so toxic that broad spectrum of animal species became effected and good result in pest control enhanced their use world-wide. Man increased the rate of use of these pesticides which gradually became accumulated in the atmosphere and brought about deprimeutal effect to every living being. In Nepal the pesticides were entered in mid-fifties in the form of chlorinated hydrocarbon and most of them are still imported from India thus owing a tremendous loss of foreign currency. They are used by farmers in the name of crop protection without thorough diagnosis of causative organism.

But it has already been known that the use of chemical pesticides against the agricultural pest posed many problems including environmental pollution, adverse effects on non target organisms and humans (Selvan et.al., 1993) and evolution of pesticide resistant pest population (Ahmad and Ng, 1981) and man's existence in this earth seemed to be of very short time. In other word, the social and environmental cost incurred by chemical control of pest have inspired the urgency on the search for strategy alternative to chemicals.

## ALTERNATIVE PEST-MANAGEMENT

In this background the biological control of noxious organisms became one and only one alternative. Because the possibilities of use of natural enemies to control these organism were already worked out in the late nineteenth (1888-1889) while the control of cottony cushion scale insect, *Icerya purchasi* was successfully done by the artificial release of two natural enemies, a parasitic fly *Cryptochetum iceryae* and a predatory lady bird beetle, *Rodolia cardinalis.* Both of these parasites and predators spread rapidly and effective and persistent control was achieved within month.

However, the successful classical and augmentative biological control of insects by insects was later shadowed by the fast growing development and domination of above mentioned chemicals. But fortunately they quickly proved to be harmful to the living world and again the alternative control strategies were to be formulated so as to foster the growing human population without destroying the biodiversity. Now the scientific community is strongly convinced to believe that it could only be brought true if biological control strategies be enacted.

## BIOLOGICAL CONTROL STRATEGY: INSPIRATION FROM NATURE

In nature there are several examples of organisms that live in or on another organism. They are popularly known as parasites, while the organisms providing food and shelter to the parasites are called hosts. The hosts suffer harms from parasites. The disease causing parasites are called pathogens and the animals that hunt, capture and kill other organisms (prey) are known as predators. Some parasites can only survive and grow in living cells (obligate parasites) and others can infect the hosts, become temporarily attached and live saprotropically when detached (facultative parasites). All these forms are useful to human beings as they can serve as natural insecticides against the pests. The method of utilizing these forms of organisms is called as biological control method. Thus biological control method can be defined as a method that involves mainly the regulation of natural enemies like predators, parasites and pathogens so that pest population can remain under control.

Biological control strategy also involves the trapping of the pest by using the substances produced by them in their secretory activities. For example there are animals which secrete and release small amount of chemical substances leading to specific physiological or behavioral responses in other member of the same species. These chemicals are called pheromones, many of which are sex attractants. That means, a smell of the chemicals (pheromones) are detectable only by the males not by other. This results in accumulation of the males around the pheromones. The artificially produced pheromones can be used in controlling the pests naturally. This method is highly useful to control the insect pest like gypsy moth.

Generally the organisms used as biological control agents may fall into different groups. They may be bacteria (*Bacillus sp.*). protozoans, helminths, arthropods and so on. For example milky disease bacterium *Bacillus popilliae* is the most widely available alternative against Japanese beetle larvae, *Popillia japonica* (Klein 1988), while the nematodes (helminths) parasitizing insects are called entomoparasitic ones. Blue disease caused by *Rickettsiella popilliae* are also pathogenic to insects (Kaya et.al., 1993). Similarly the predators like lady bird beetles, praying mantids etc. can also be used as the bio-control agents. But their artificial production and mass release are of tremendous difficulties. However, the one which can be produced in industrial scale and released in large quantities are nematodes, particularly rhabditids like *Steinernema* and *Heterorhabditis*.

## PRESENT SITUATION OF BIOLOGICAL CONTROL STRATEGY BY THE USE OF ENTOMOPATHOGENIC NEMATODE

Although presently limited to high value crops (Ehlers & Peters, 1994) entomopathogenic nematodes (Parasitic nematodes causing disease to the insect host due to the bacteria associated with them) have successfully been used against black vine weevil in Australia and Europe., currant borer in Australia and the peach borer moth in China and have been expected to be very successful and suitable for developing nations to use in insect control programs (Bedding, 1990). But at the present time only the develolped countries are pursuing several intensive researches in seeking potent strains of microorganism for controlling specific insect pest. As already mentioned that it is unfortunate for Nepal to be still very far from such activities. However, it has gradually been felt that the developing nations also must start such strategies to be implemented so as to pursue sustainable developmental processes. Even if, the microbial species such as *Bacvillus thuringensis, B. popillae* and *B. sphaericus* have been reported (personal communication with Department of Microbiology, T.U.), the works on their collection, strain identification, mass production, efficacy test also have yet to be started.

## RHABDITIDS AS POTENT BIOCONTROL AGENTS

Of the four groups of entomoparasitic nematodes (mermithids, tylenchids, aphelenchids and rhabditids) used as antagonists of agricultural insect pests, only a few species of them have so far been used for biological control purpose as they are proved to be entomopathogenic and are advantageous over chemical and microbial insecticides in their ability to locate and kill even well-hidden insects (Bedding and Miller, 1981). They are rhaditids of the genera *Steinernema* and *Heterorhabditis.* They serve as vectors for pathogenic bacteria, *Xenorhabdus* and *Photorhabdus* (Putz et.al., 1990) and are pathogenic to almost all insects so far tested (Pionar, 1979). They are obligate parasites with the third stage juveniles living in soil and surviving for several months, even years, without feeding. This infective third stage nematode, also known as dauer juvenile (DJ), is attracted to insects (Bedding & Akhurst, 1975) and enter a host either through natural body openings (Poinar, 1979) or through inter skeletal membrane (Bedding & Molyneux, 1982). Once inside the host the DJ releases its symbiotic bacteria (*Xenorhabdus*) carried monoxenically in its intestinal lumen (Bird & Akhurst, 1983; Endo & Nickle 1991) into the haemolymph of the host. The bacteria proliferate vigoroulsy causing septicemis and death of the host within two days after DJ's entrance and establish suitable condition for the reproduction of the nematodes by providing nutrients and inhibiting the growth of other microorganisms (Poinar, 1979). The DJs give rise to first generation female (bi-sexual in *Steinernema* and hermphrodite in *Heterorhabditis)* in about five days. The female lays eggs which becomes the second bisexual generation. The progeny from this or a third generation usually develop into infective dauer juveniles which emerge from the insect cadaver in search of a new host.

## EFFICACY OF ENTOMOPATHOGENIC NEMATODE

The natural occurrence range of these nematodes in the soil may fluctuate from 10 to 60 percentage (Akhurst & Bedding 1986). This range has lead nematodes to be more successful because more than 95% of all the agricultural insect pests spend at least part of their lives in the soil where several kinds of them parasitize different kinds of insects.

Perhaps no insects are left uninfected by nematodes. White grups, the larvae of Scarabaeidae, are major pests of sugar cane, maize, potato, turf grass, pastures and forest throughout the world. Similarly many weevils (Coleoptera, Curculionidae) are the pests of the pastures, turfs and agricultural as well as horticultural crops and larvae of blackvine weevil *Otiorhynchus sulcatus* are major pests of green house and nursery plants world wide. All of these pests are often very difficult to kill even by chemicals. In such cases the entomopathogenic nematodes are found to be much successful because they are more succeptible to the nematodes. These nematodes are also found to infect on ticks, *Boophilus annulatus* (Samish & Glazer, 1992). They are also found successful (80-87%) against termites (Poinar & Georgis, 1989) and in several instances found to infect mole crickets, fire ants, fruit fly larvae, melon fly and Colorado beetles (Klein, 1990).

Although nematode pathogens are ubiquitous they donot always exert the same efficacy in all places. For example *Steinernema glaseri* has given over 80% reduction of scarabaeid larvae in sugarcane in China (Wang & Li, 1987) but did not give the same result in other fields (Sosa & Hall, 1989). *Heterorhabditis bacteriophora* in a New Zealand are found to be more effective than any other nematode (Hoy, 1955). Encouraging results upto 100% mortality of citrus weevils (*Diaprepes abreviatus*) was found in one experiment (Schroeder, 1989).

## STRAINS IMPORTANT TO NEPAL

There are different strains of the same species of nematodes able to be effective in different geographical and climatic zones. In Nepal also, the main agricultural cash crops are subject to severe damage of plants in the field and ultimate loss in yield by soil dwelling insects. Let us take the example of maize (Zea mays) and potato (solanum tuberosum) which are the two major crops grown in hilly region of Nepal. Maize has been used as a major cereal for human food and animal feed and is the number one food cereal of hills and the second most important crop of Nepal, covering 28% of the total cropped areas (of about 744,000 ha) with a total production of 11,68,000 MT. It is grown both during summer and winter with an average yield of 1.57 MT/ha (National Planning Commission 8th Five year plan 1992-97). Potato occupies the 5th position on acreage of land and 4th on production in Nepal. It is the major cash in the hilly region. The climatic diversity in Nepalese hills permits a round year cropping for potato cultivation. As these are cultivated alternatively or both at a time, they have a common serious insect pest, a polyphagous insect in the family Scarabaeide (Coleopetera) commonly referred to as scarab or white grub. The grubs feed on root and tubers and are most destructive at the seedling stage of maize and potato tubers. They remain dormant inside soil (10-14 cm) during the winter months and start damaging crops during the warmer months (February onwards). Adults oviposit 4-6 cm in the soil. After 15-20 days the eggs hatch into one cm long white grubs which when full grown reach upto six cm. They feed for 90-100 days and undergo for the pupal stage that lasts for 18-21 days.

However, the data on estimation of damage and loss caused by scarabaeid beetles and their grubs are not available in Nepal but almost every farmer complains about the severe destruction caused by these pests. Until today, the only method recommended for control of them in Nepal is the application of 5% Chlordane @ 40-80 kg/ha and 5% aldrin or heptacholor @ 20-45 kg/ha. The high cost of the insecticides, ineffectiveness of most of them due to the development of resistance against them by white grubs, and the detrimental effects to the environment has required an immediate need to develop a cheaper, effective, environmentally safe and residue free pest control method. Besides, the banned systemic pesticides like BHC, DDT, are still in use in Nepal because the indigenous entomopathogenic nematode strains are not yet identified.

## BIOCONTROL BY NEMATODES: SUSTAINABLY RELEVANT

The adverse environmental effects of chemical control of the insect pests have been well known in the form like (i) killing of the non-target organisms inlcuding beneficial natural enemies (ii) ground water pollution resulting in human health hazards and (iii) development of pesticide resistant strain of target pests. Whereas, the use of bioinsecticides would lead to a substantial reduction in use of these toxic chemicals, which are at present recommended at a very high dose (5% Chlordane @ 40-80 kg or 5% Aldrin @ 20-45 kg dust/ha.) for white grub control in Nepal and in other similar climatic regions of globe, where they are major pests of such food crops.

## CONCLUSION

It is obvious that the insect parasitic nematodes are naturally occurring components of many soil ecosystems and are already being used in several countries for biological control of insect pests. In addition to this, their symbiotic bacteria are specific to arthropods, have no side effects on humans and other vertebrates (Gaugler & Boush, 1979; Poinar et.al. 1982). Furthermore, they pertain a long-term controlling effect to the most dangerous soil dwelling insects. Therefore, it could result not only in the benefits to the environment but to food quality and increased levels of production, and also the tendency of foreign exchange drainage towards the import of pesticides will be greatly reduced. As the majority of holdings producing maize and potato are small in size, the cost benefit will accrue particularly to small scale farmers. Hence this is high time to start with works in the use of bioinecticides in Nepal.

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