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Application of Nano Technology and Nano Materials for Remediation of Water Pollution, and Global Warming Using the Catalytic Oxidants, Nisar-Data and Magnetic Refrigeration Technology

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Abstract

Meaning: *"The Supreme Lord, the Creator of all realms, has established the Earth in its orbit through His divine control. He has set the heavenly world (Dolak) in the pillar less expanse of space.*

Objectives i.e. Statement of Problem*: The present study endeavours to obey the command of the great Almighty for Divine's Cosmic Establishment by harnessing the ocean of cloud-borne waters and by using the conventional and modern innovative technologies to depollute water by making use of innovative technologies e.g. Nanotechnology and Nanomaterials for remediation of Water Pollution by employing Physicochemical and Spectroscopic methods to characterize the in-situ chemical speciation of the inorganic contaminants.*

Next, it aims to use Nanotechnology and Nanomaterials for remediation of Water Pollution by using Catalytic Oxidants of first row of transition metal oxides in the Water Treatment Processes and to entrap toxins, by employing High Affinity Toxin Receptors (HART). Also, Nanotechnology and Nanomaterials would be applied to study Chemical Reaction Kinetics to assess water contaminant transformation. Further, it would be investigated whether Nanotechnology and Nanomaterials can be used to Control Global Warming by converting GHG (Methane) to ethanol by catalytic processes and in developing hybrid fuels like bioethanol and biodiesel and go for electricity from biomass. Also, by using cooling technologies like 'Magnetic Refrigeration Technology'(VG-MRT), developed by the author in the past, would be employed to replace Chlorofluorocarbons in the refrigeration and air-conditioning; to Control Global Warming vis-a-vis Climate change.

Keywords: Comic-Based Reading Materials, Reading Comprehension Difficulties, Effectiveness, Schema Theory.

Introduction to Nanotechnology and Nanomaterials

Nanotechnology encompasses the nanomaterials or nanoparticles (NPs) having the nano nanosized dimension ranging between 1 and 100 nanometres(nm), and these are capable to enhance not only their physical and chemical characteristics but biological effectiveness as well. These Nanomaterials contain larger surface area per unit volume with respect to their macro-counterpart, and hence do have higher catalytic activity, higher rate of reaction kinetics due to higher chemisorption/ absorption properties and be useful in detoxification of toxic gases and absorbing Green House Gases (GHS) responsible for Global Warming vis- a- vis Climate change.

Also, these nanoparticles have got better interaction with other materials and are good transporters of clean energy as well as act good nano fertilizers, nano-pesticides in agriculture resulting better productivity and maintaining ecological balance. Nanotechnology covers vide spectra of its utility in almost all

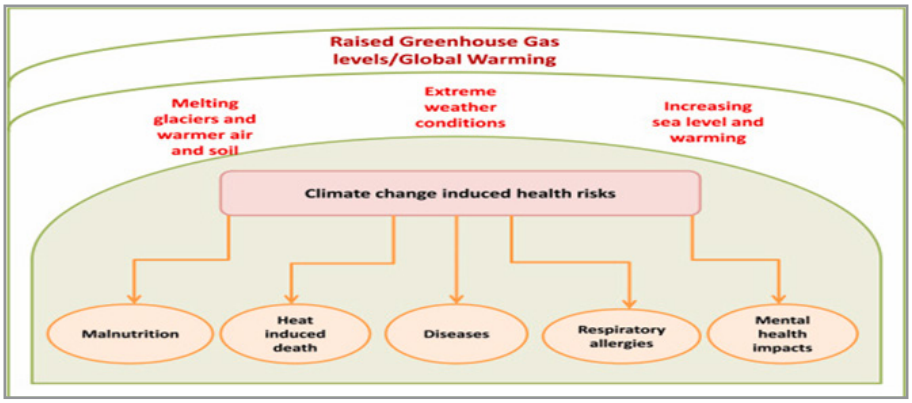
the fields like medicine, health, environment (Land, Ocean, ice), food, material, planetary, Geological, Chemical, Physical sciences and even creating nanotechnological tools for the diagnosis and treatment of diseases. For example, Nano sensors play key roles in the detection of agroclimatic conditions for food corps and supervision other parameters related to, pesticides, herbicides, fertilizers while the nano biosensors are used in food packaging.

Moreover, nanostructure materials e.g. nanocomposites, nano catalysts, nano-coatings, nano lubricants etc. are environmental friendly in comparison to their conventional counterparts. The oxygen, nano catalyst helps in complete combustion of fuels, and especially in the REDOX reaction useful not control Global Warming by chemical processes by reducing the greenhouse gas emission. Similarly, nano lubricants and nanocoating's help to decrease friction in engine which significantly reduces CO2 emission.

The Nanotechnology products/NPs are used in improving the efficiency of renewable energies (e.g., biofuels, solar and hydrogen fuel cells), and thereby, reducing the dependency on fossil fuels and thus controlling the Global Warming Environmental pollution , and remediation by degrading dyes and other colourless pollutants in wastewater streams as well as producing nanostructured materials involved in green architecture in the form of nanocomposites, nano coatings, nano glass, carbonic nanotubes, nano silica, and polymeric structures in roof, windows, wall coatings, insulation, energy storage, solar cells, and a refrigerant free cooling for energy efficient sustainable constructions/buildings and the nontoxic environment.

Effects of Global Warming vis-à-vis Climate Change

Global Warming vis-à-vis Climate variability has impacted almost all sectors of human's life spanning from environmental, agriculture, health and by can be realised as entirely altered the climatic system and weather patterns of our earth in form of increase of warmer land, warming air, warmer ocean, changing ocean currents, ocean acidification, rising sea levels, changes in hydrological cycle, flooding, melting glaciers and sea ice and extreme adverse weather conditions in terms of intensity and frequency. Not only that, the climate change due to Global warming causing effect on health and the economy of Nations.



The Health Effects Induced by Climate Change are Shown in Fig 1: (C.f. Google Search)

Types of Nanomaterials

Nanomaterials/nanoparticles/nanostructures are of nano size (approximately 1–100 nm) exhibit extraordinary physical, chemical and biological properties and on the other hand Nanotechnology deals with the design, production, manipulation and application of nano structured materials/nanoparticles. These are categorized as advanced nanomaterials (viz. super, smart, active and swarms' nanomaterials).

Super/Nano Pure Nanomaterials

In these each atom is at its perfect geometry, strong and defects free that could be further improved using nano engineering e.g. wings of aircraft and diamond bolts.

Smart Nanomaterials: These can respond to any signal/command and can change size, shape, colour, density or any physical property like refraction of light by rearranging the atoms. Active Nanomaterials: consist of sensors, actuators and computers and are capable to check out its environment, tract a change and respond.

Swarms' Nanomaterials: These are active nanomaterials composed of various nanomachines that work collectively to fulfil a specific goal.

Though there are numerous nanomaterials according to their nature and applicability. The Few of Nanomaterial are Listed in Fig 2: with their Major Applications and Utilities.

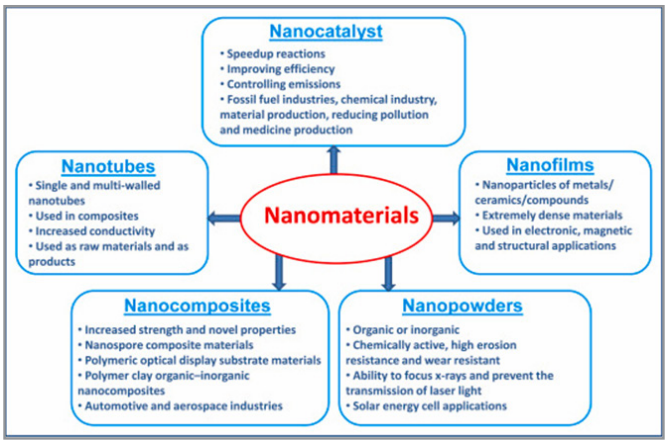


Figure 2: Different nanomaterials with their important features and potential applications (c.f. Google Search).

Nano Technology and Nano Materials in Remediation of Water Pollution, and Global Warming

Nanotechnology has proposed various sustainable approaches to a number of environmental problems such as wastewater treatment, greenhouse gas emission, fuel crisis, remediation of various pollutants, water pollution etc. that may cause climate change (Fig. 3)

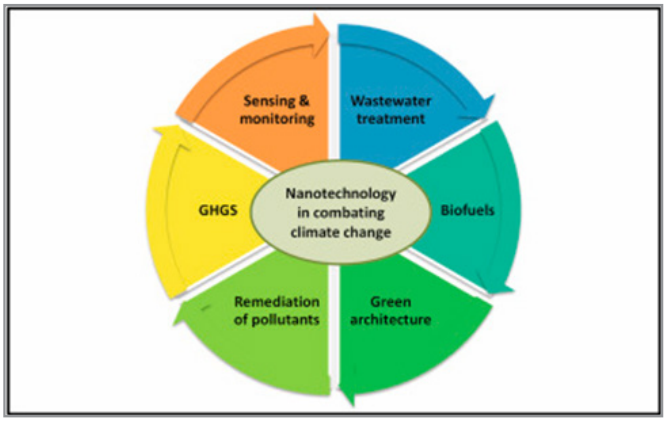


Figure 3: Various Applications of Nanotechnology in Combat

The climate change results due to Global warming, Polluted air, polluted water and polluted soil, polluted environment unfit for living due to the diseases (respiratory and skin diseases, cancer etc.), global warming, acid rain, ozone depletion etc. The environmental nanotechnology (E-nano) based products may be employed for the environmental remediation applications by using Nanotechnology based processes to control water pollution and treat the pollutants, and toxic materials.

Nano-Bioremediation of heavy metals and other pollutants from wastewater

Water is one of the most essential substances on the earth for living beings and the availability of clean and potable water has become a challenge due to water pollution, Global Warming and climate variability. Due to shortage of clean water, unconventional resources (e.g., seawater, contaminated fresh water, brackish water, stormwater and wastewater),the challenge is to treat this water and make it useable. The current multifunctional methods of nanotechnology with better performance for water treatment includes Adsorption, membrane separation, photocatalysis, disinfection, monitoring and sensing. Fig. 4.

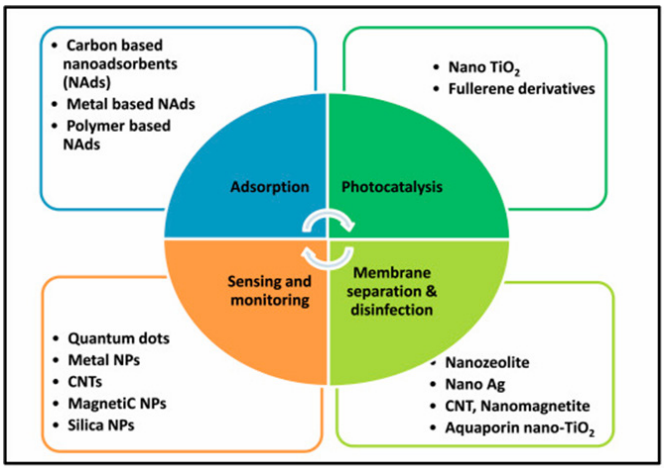


Figure 4: Water treatment processes to degrade the pollutants by the treatment with a range of nanomaterials. (c.f. Google Search)

NISAR-Satellite Data: <Space.com30July25> reported the launch of NISAR-Satellite and released the launch-video as well. NISAR (NASA-ISRO) Satellite launched by ISRO- Geo-synchronous Satellite Launch Vehicle (GSLV) on 30th Jul'25, is a joint effort between NASA and ISRO. It aims to study Earth planet in detail from orbit for at least five years using Synthetic Aperture Radar (SAR), capable to gather data in all weather and lighting conditions.

In the word of ISRO Officials, "NISAR will image the global land and ice-covered surfaces, including islands, sea ice and selected oceans every 12 days," .NISAR's "primary object land and ice deformation, land ecosystems and oceanic regions in areas of common interest to the U.S. and Indian science communities," they added.

The NISAR launch is the 18th liftoff to date for the GSLV, an expendable three-stage rocket that stands 169.6 feet (51.7 meters) tall , 5,300-pound (2,400-kilogram) in weight deployed into orbit about 18.5 minutes after liftoff on 30thJuly 2025. It would work from a circular orbit 464 miles (747 kilometres) above Earth that takes it over the planet's poles.

Also, NISAR is a dual-frequency band radar. The L-band radar, which transmits microwaves between 1 and 2 gigahertz (GHz), was built by NASA's Jet Propulsion Laboratory (JPL) in Southern California, while ISRO provided the S-band radar operating between 2 to 4 GHz. The S-band is sensitive to vegetation and foliage, whereas the L-band can see through the trees to monitor the bare surface, be that rock or ice.

The Synthetic Aperture Radar SAR technique gives NISAR powers of high resolution, and it takes advantage of the moving capacity of the NISAR wherein; spacecraft beams down radar pulses while flying along, the area on the ground covered by each radar beam while switched on is about 10 kilometres (6 miles) long.

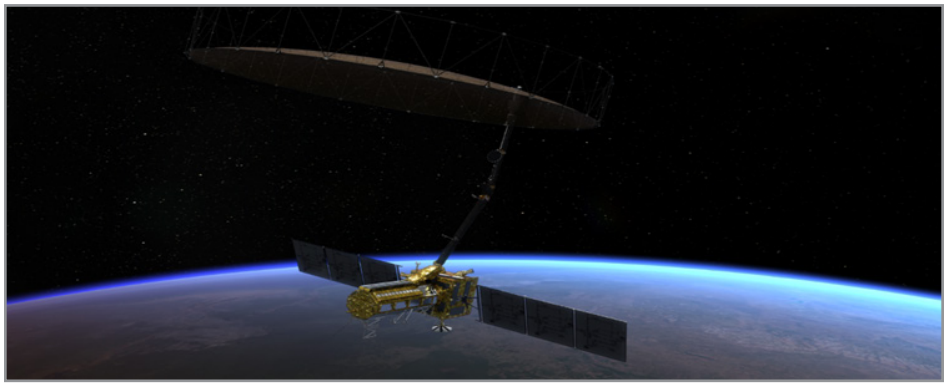


Figure 5: The Synthetic Aperture Radar SAR

The NASA-ISRO Synthetic Aperture Radar is capable to scan Earth planet and provide detailed map of the ground or ice creeping by degrees of less than a centimetre helping to avert, or minimize, the effects of natural disasters e.g. Earthquakes, Volcanoes, land subsidence, swelling, and the movement, deformation of melting of ice sheets , glaciers, and tracking of wildfires and floods.

This would help to predict Earthquakes in particular, by tracking the smallest shifts in the landscape as the precursor to a major disaster. For example, the "slow" landslides in mountainside or cliff move by just a few centimetres per day, before reaching a tipping point and crashing down would be observed by NISAR enabling to see that slow creep/subtle movement of tectonic plates, and forecast the when and where the disaster would take place.

Figure 7: The GSLV rocket carrying the U.S.-Indian NISAR Earth-observing satellite rolls out to the launch pad on July 24, 2025. (Image credit: ISRO).

Application of Nano Technology and Nano Materials in developing Physicochemical and Spectroscopic methods

These would be developed to convert toxic gases e.g. Green House Gases (CH4, NOX,) and other toxins into non-toxic entity using vis-à-vis Climate Change by using Catalytic Oxides of the first row of transition metals in the Periodic Table of Element.

Similarly, these Catalytic Toxic Absorbers would be developed to absorb toxic gases e.g. Green House Gases (CH4, NOX,) and other toxins using Chemisorption, Surface Area, Magnetic Susceptibility, Differential Thermal Analysis, and Catalytic activity, employed by the author and explained.

Physicochemical and Spectroscopic methods: to characterize the in-situ chemical speciation of the inorganic contaminants would be used to develop Predictive Model of Chemical Reaction Kinetics (PM-CRK) for remediation of water pollution by catalytic oxidants.

The Oxidation process would be employed to treat Groundwater contaminants by making use of the chemical oxidant s viz. hydrogen peroxide, persulfate, permanganate & ozone. These oxidants have been able to cause the rapid and complete chemical destruction of many toxic organic chemicals; other organics are amenable to partial degradation as an aid to subsequent bioremediation.

When solutes are introduced into groundwater systems or into surface waters, complex physicochemical reactions occur between the dissolved solutes and native solid materials. Knowledge of these complex interfacial reactions is required to assess the impact of such inputs on water quality in aquatic and terrestrial ecosystems. Assessments of water quality and efforts to restore contaminated waters depend strongly on a fundamental understanding of geochemical processes involving reactions with mineral surfaces and substrates. Such processes include weathering reactions that contribute dissolved chemicals, sorption that removes aqueous species, and electron transfer mechanisms that establish redox conditions.

6.3 Water gets polluted due to toxins & toxic gases. There are generally four types of toxic entities: chemical, biological, physical and radiation. Chemical toxicants include inorganic substances such as, lead, mercury, hydrofluoric acid, and chlorine gas, and organic compounds such as methyl alcohol.

Hence, the focus is to develop innovative methods to entrap toxins, by developing High Affinity Toxin Receptors (HART), converting GHG (Methane) to ethanol by catalytic processes and develop hybrid fuels like bioethanol and biodiesel and go for electricity from biomass.

It's presumed that catalytic oxides of first row transition metal oxides e.g. Cobalt oxide should optimize the process of subsurface remediation and above-ground water treatment systems depending on a variety of site-specific conditions e.g. reaction rate kinetics. Chemical oxidation is applied in subsurface systems and in above ground water treatment systems involving chemical oxidation regeneration of granular activated carbon (GAC).

Also, to correlate Physicochemical properties of these catalytic oxides of first row transition metal oxides, to discuss strategies to control Global Warming and remediation of Water pollution resulting due to toxin, toxic gases, GHG (Green House Gases), to save marine life (under water).

Past Research

Goswami VK et.al. found that Cobaltous Oxide is a good catalyst for oxidation reactions. The existence of two forms of cobaltous oxide possessing different physico-chemical properties have been reported.

The form I, Co O(I) (prepared by heating cobalt metal in carbon dioxide at 1000deg.C) has a NaCl structure. The form II, Co O (II) (prepared by decomposing cobalt carbonate at 300deg.C in vacuum) has a NaCl structure with half of its (+) ve ion sites and half of its (-)ve ion sites vacant.

The density measurements have shown that Co O (I) has a density of 6.4 grams / cm3 whereas, Co O (II) has a density of 4.8 ± 0.5 grams per cm3.

7.1. The same authors have also found that Co O (II) transforms noticeably to Co O (I) at about 300deg.C, giving Co O (I, II) – a mixture of form I and II. It remains to be investigated which of the two forms of cobaltous oxide is mainly responsible for the catalytic activity, through a study of the physical properties of the two forms and their catalytic activities.

HT; 29Apr'17 reported that the particles in the polluted air can travel from lungs into our blood stream resulting the increase of risk of heart attack or strokes since Nanoparticles in air pollution have been associated with cardiovascular disease leading to premature death. As per the State of Global Air 2017 Report, released in Boston on 14 Feb'17, as many as 2.54 lakhs death occurred in 2015 on account of exposure to ozone and its impact on chronic lung disease.

7.2..Ref: Hindustan Times,14 Feb'17), Researchers in University of Washington ,USA & University of Edinburgh found that the pools underneath the glacier, Thwaites, which is on the edge of West Antarctica, Amundsen Sea are draining out at an unprecedented rate and emptying themselves resulting of global sea level rise as well as have an impact on local water supplies & give rise to Water Pollution as per my presumptions.

On 02 May 17(Times of India), at British Columbia university Canada, Prof. Pierre Berube has developed a low maintenance water filtration system using the technology which combines microbes and gravity using ultra-filtration membranes, which is very fine screen that removes not just particulate matter but, also large molecules, e.g. disinfectants or herbicides, pesticides and contaminants from water e.g. microbial pathogens, viruses and bacteria.

Research Methodology

To evaluate correlation of chemical oxidants with chemical species associated with soil, aquifer materials, and contaminants during water treatment processes.

The aim of the research is to examine some of the solid-state work pertinent to catalysis on oxide and explore further the relationship between them. The emphasis in the introduction will therefore be laid on developments in our knowledge of the structure and properties of the solid state and on the background to the fields of chemisorption and catalysis.

The present investigations on the Study of the relationship between the physicochemical characterization and catalytic activi-

ty of catalysts having the same electronic configuration,

8.1 such as Co O(I), Co O(II) and Co O (I, II); have been undertaken to find out which of the two structures 3d6 or 3d7 of the oxides is the more active configuration for catalytic reactions involving hydrogen and /or hydrocarbons.

The oxide, prepared either by decomposing nitrates /oxalates or by heating the lower oxides in oxygen, were characterized by (I) X-ray diffraction pattern (II) differential thermal analysis (III) magnetic susceptibility measurements (IV) surface area determination and (V) chemical analysis.

The catalytic activity of the oxides, cobaltous oxides, i.e. Co O(I) and Co O(II) and the mixed form, Co O (I, II) were investigated through a study of the dehydrogenation of cyclohexane at initial cyclohexane pressure of 100 psi in the temperature range 120deg.C to 250deg.C.

The experiments were carried out under static condition in a pressure vessel specially designed for the purpose. Hydrogenation of ethylene over Co O(I), Co O(II) and Co O (I, II) at selected temperature only has also been studied. The catalytic behaviours of the two forms of Cobaltous oxides have been examined in the light of their physical characteristics (as observed by differential thermal analysis and magnetic susceptibility measurements) and it has been suggested that factor other than 3d configuration need be considered in such correlative studies.

Method of Characterization of the Catalysts

The oxides, prepared either by decomposing nitrates/oxalates or by heating the lower oxides in oxygen, using the apparatus designed by Dr. Virendra Goswami, at IIT Kharagpur and the individual oxides) were characterized by (i) X-ray diffraction analysis (ii) differential thermal analysis (iii) magnetic susceptibility measurement (iv) surface area determination; and (v) chemical analysis.

Results and Discussion

The results of Magnetic Susceptibility measurement and DTA are shown in figure 11 respectively.

The magnetic susceptibility data of the two forms of Co O and the mixture show that Co O(II) has got the highest magnetic susceptibility value at room temperature (5231 x 106 grams/mole), in comparison to the room temperature susceptibility values of Co O(I) (4684 x 106 grams per mole) and Co O (I, II) (4762 x 106 grams/mole). This arises from the low density of Co O(II) compared to Co O(I) and Co O (I, II).

Along with the temperature dependence of magnetic susceptibility of Co O (I, II), Co O(I) and Co O(II), the magnetic susceptibility data of La Blanche Tais has also been shown in figure 11 The sample-to-sample variation in the region 300deg – 600deg K indicates that the magnetic susceptibility depends profoundly on the sample preparation. The plot of Xm-1 vs T in Co O (I, II) follows a linear relationship whereas Co O(I) shows a slight curvature, increasing in the case of Co O(II).

Further, in Co O(II) the susceptibility shows an anomalous behavior in the temperature region 550deg – 600degK; indicating that in this temperature range Co O(II) slowly passes into Co O(I). Beyond the transition region all the samples show a similar behavior. This result is in conformity with the Mossbauer data.

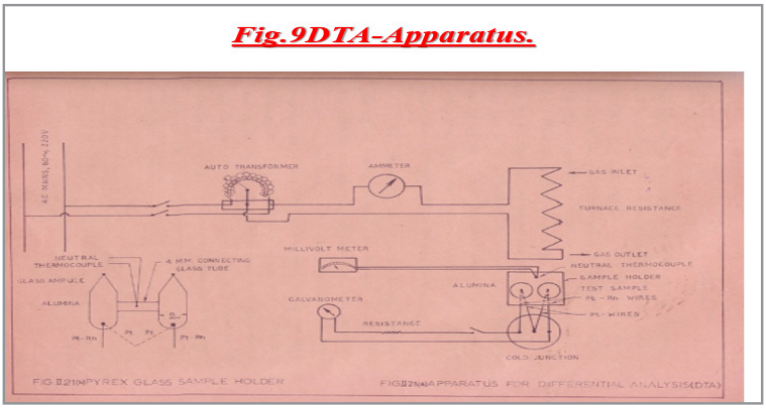


Figure 9

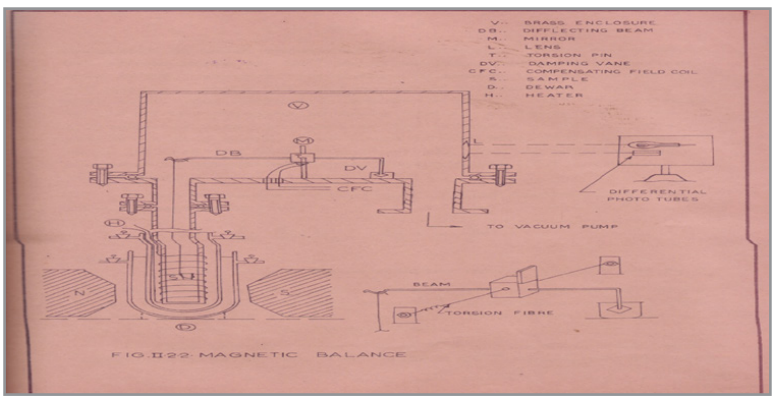


Figure 10: Specially Designed and fabricated Magnetic Balance at IIT Kharagpur.

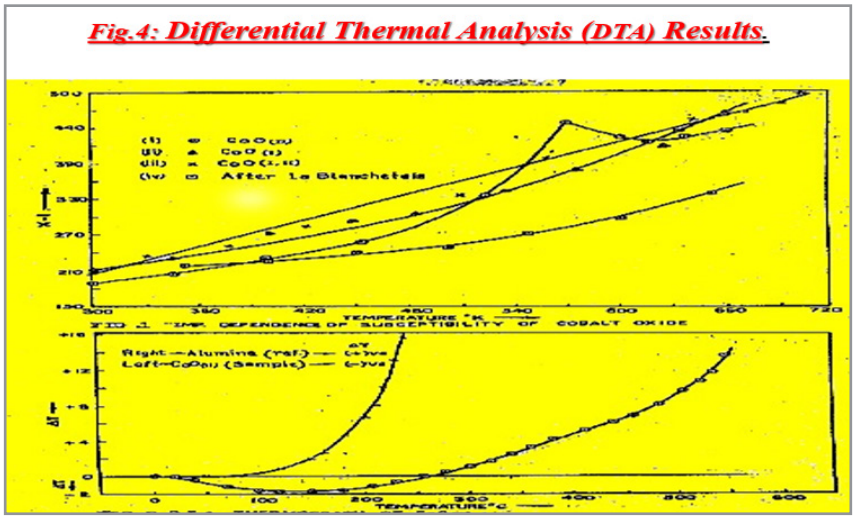


Figure 11: Flow Diagram for Dehydrogenation of Cyclohexane, IIT Kharagpur C. f (Ph. D Thesis Submitted by Dr. Virendra Kumar Goswami (Author)

NISAR -Satellite Data: <Space.com30July25>

Water treatment processes to degrade the pollutants by the treatment with a range of nanomaterials. (c.f. Google Search, 30 Jul'25))

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