Acid-Base Indicators For Functional Applications

Ram W. Sabnis

Squire, Sanders & Dempsey LLP

San Francisco, CA, USA

COC-2007,
Mumbai, India

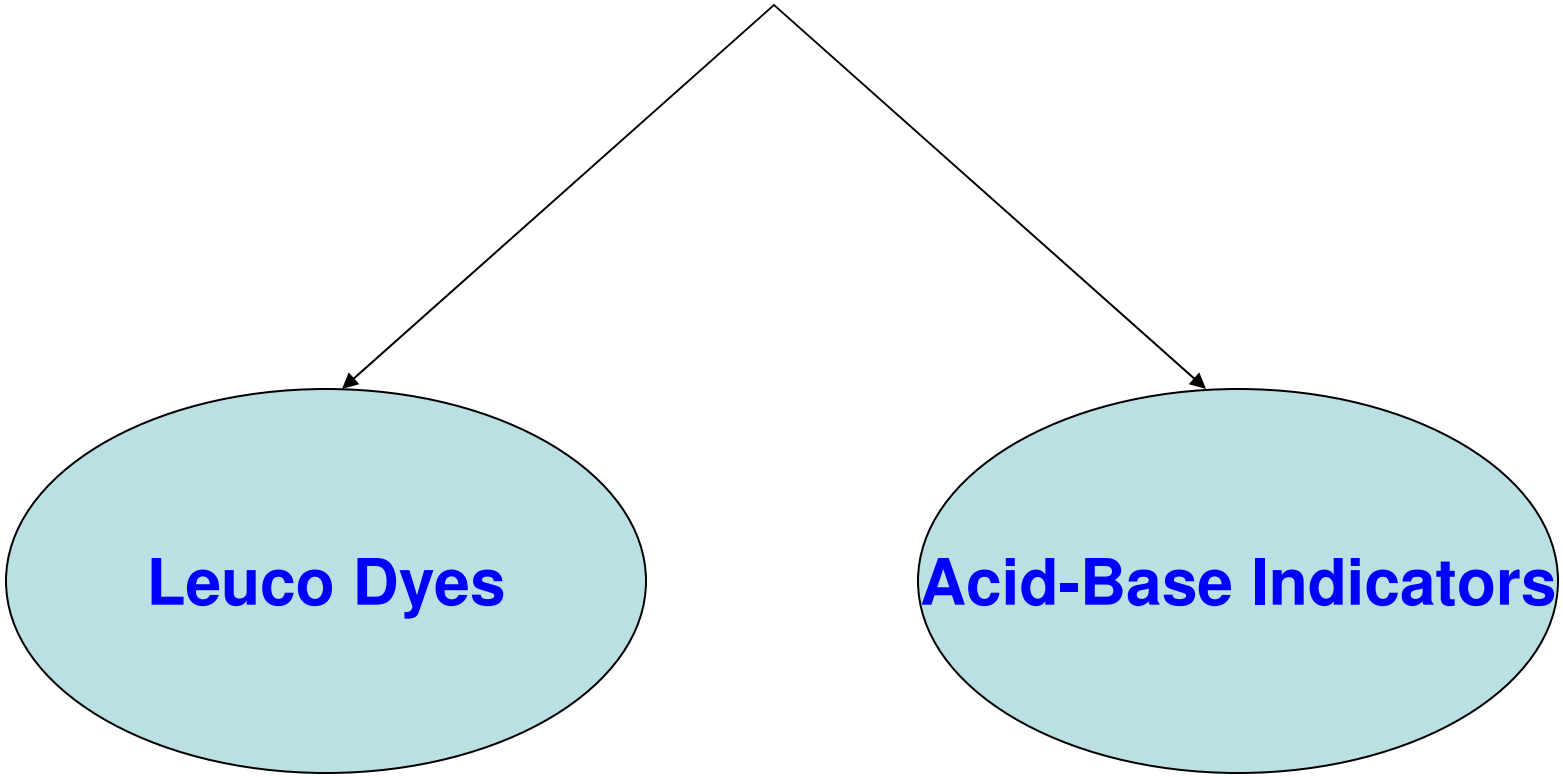
ramsabnis@yahoo.com

Colour-change Concept

- Coloured to colourless
- Colourless to coloured
- One colour to another colour
- One colour to second colour to third colour

ramsabnis@yahoo.com

Commonly used colour-change systems



ramsabnis@yahoo.com

Colour-changing Systems

Leuco Dyes

- Colour former
- Phenol
- Long chain alcohol

ramsabnis@yahoo.com

Leuco Dye System Limitations

- 3-Component system
- Multi-step synthetic procedures of colour former
- Poor yield/purity
- Only solvent based (alcohol)
- Not applicable to aqueous systems
- Very few commercially available
- Cost

ramsabnis@yahoo.com

Acid-Base Indicators

- 1-Component system
- Facile synthesis
- Excellent purity & yield
- Can be used in solvent as well as in aqueous systems
- Commercially available
- Inexpensive

ramsabnis@yahoo.com

Classification

- Azo
- Benzein
- Nitro
- Phthalein
- Sulfonephthalein
- Triphenylmethane
- Fluorescent
- Miscellaneous

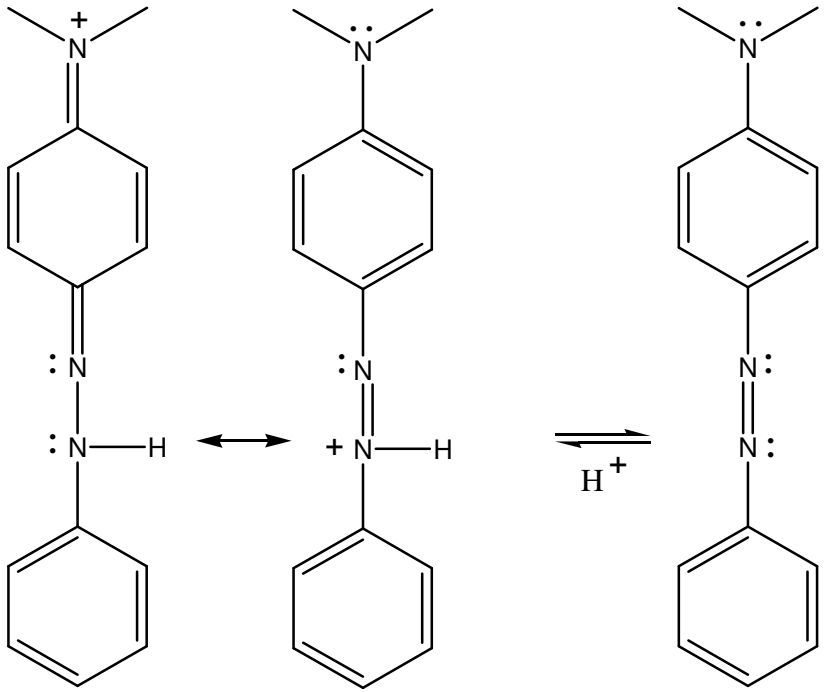
ramsabnis@yahoo.com

Azo Acid-Base Indicators

COC-2007,
Mumbai, India

ramsabnis@yahoo.com

Colour-change Mechanism



Red

Acid Form

Yellow

Alkaline Form

ramsabnis@yahoo.com

Colour Transition

Indicator	pH Range	Colour Change
Acid Blue 89	11.0-12.0	Blue to red
Acid Blue 92	11.0-12.0	Blue to pink
Alizarin Yellow GG	10.0-12.0	Yellow to orange
Alizarin Yellow R	10.0-12.1	Yellow to orange-red
Benzopurpurin B	1.3-4.0	Blue-violet to red
Brilliant Yellow	6.4-8.0	Yellow to red-orange
Calmagite	7.1-9.1	Red to blue
Carbazol Yellow	12.0-14.0	Yellow to red
Chrome Orange GR	10.5-12.0	Yellow to red
Chrysoidin	4.0-7.0	Orange to yellow
Congo Red	3.0-5.0	Blue to red
4-Dimethylamino-2-methyl-azobenzene	2.8-4.4	Red to yellow
Direct Blue 72	13.0-14.0	Blue to violet
Ethyl Orange	3.4-4.8	Red to yellow
Ethyl Red	4.5-6.5	Red to yellow

ramsabnis@yahoo.com

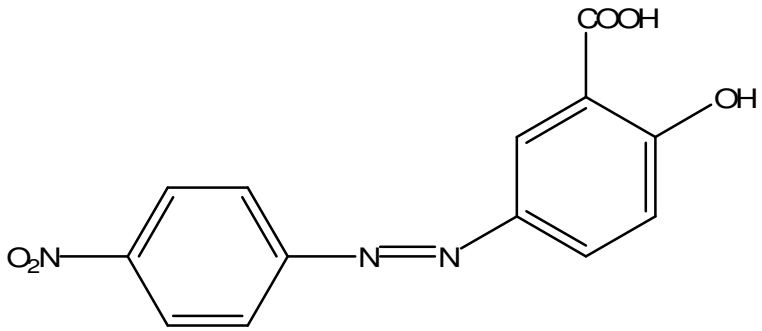
Colour Transition

Indicator	pH Range	Colour Change
Lanacyl Violet BF	11.0-13.0	Violet to orange
Metanil Yellow	1.2-2.3	Red to yellow
Methyl Orange	3.0-4.4	Red to yellow
Methyl Red	4.4-6.2	Red to yellow
Methyl Yellow	2.9-4.0	Red to yellow
α-Naphthyl Red	3.7-5.0	Red to yellow
Nitrazine Yellow	6.0-7.2	Bright yellow to bright blue
4-(Phenylazo)diphenylamine	1.2-2.5	Red to yellow
Propyl Red	4.6-6.6	Red to yellow
Solochrome Violet RS	6.5-9.0	Orange-red to violet
Thiazol Yellow G	11.0-13.0	Yellow to red
Tropaeolin O	11.0-12.7	Yellow to red
Tropaeolin OO	1.4-2.6	Red to yellow
Tropaeolin OOO	7.4-8.6	Amber to orange
	10.2-11.8	Orange to red

ramsabnis@yahoo.com

Alizarin Yellow R: Applications

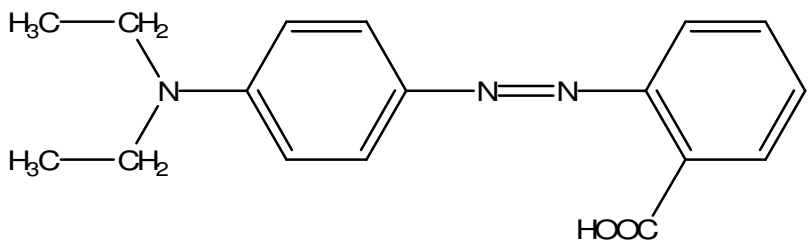
- Display Device
- Photoresists
- Nanoparticles
- Sensors
- Photoconductive materials
- Photography
- Copying materials
- Optical Engineering applications
- Cosmetics
- Diapers
- Food storage
- Measurement of acidity in juice
- Determination of albumins
- Counting leukocytes
- Antifungal agent



ramsabnis@yahoo.com

Ethyl Red: Applications

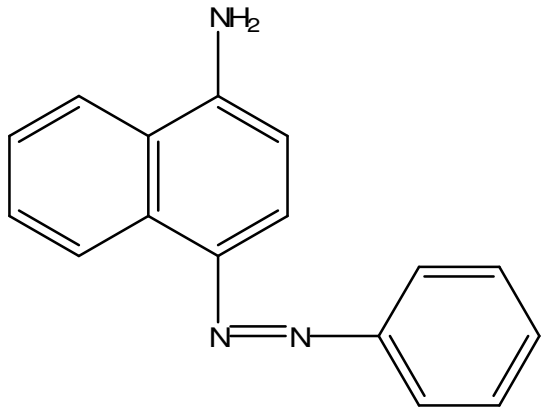
- Optical materials
- Photoresists
- Flexible electronic circuitry
- Counting leukocytes
- Enzyme binding assays
- DNA chips



ramsabnis@yahoo.com

α-Naphthyl Red: Applications

- Display Device
- Semiconductors
- Sensors
- Photosensitive materials
- Recording materials
- Imaging materials
- Inks
- Lubricants
- Hair dyes
- Food storage
- Dental materials



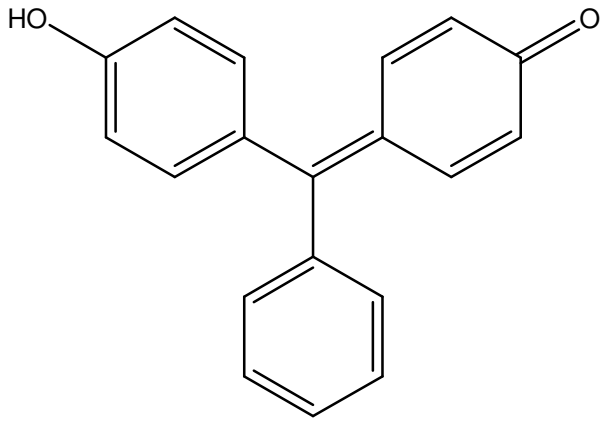
ramsabnis@yahoo.com

Benzein Acid-Base Indicators

COC-2007,
Mumbai, India

ramsabnis@yahoo.com

General Benzein Structure



ramsabnis@yahoo.com

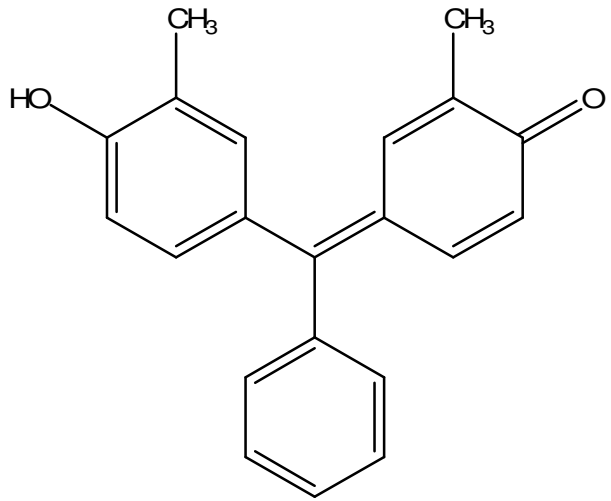
Colour Transition

Indicator	pH Range	Colour Change
o-Cresolbenzein	7.2-8.6	Yellow to red
Dibromothymolbenzein	5.6-7.2	Yellow to blue
α-Naphtholbenzein	9.8-11.0	Brownish to green-blue
Phenolbenzein	6.0-7.6	Yellow to red
Thymolbenzein	1.5-2.5	Red to yellow
	7.6-9.0	Yellow to blue

ramsabnis@yahoo.com

o-Cresolbenzein: Applications

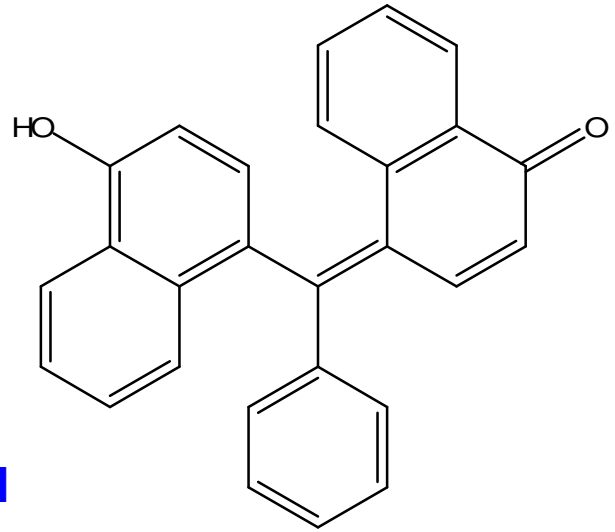
- **Cosmetics**



ramsabnis@yahoo.com

α-Naphtholbenzein: Applications

- Semiconducting polymers
- Concrete
- Correction fluid
- Food storage
- Determining bacterial growth in packed food
- Personal hygiene products
- Detecting viable cells
- Detecting enzymes
- Detecting bacterial growth in patients



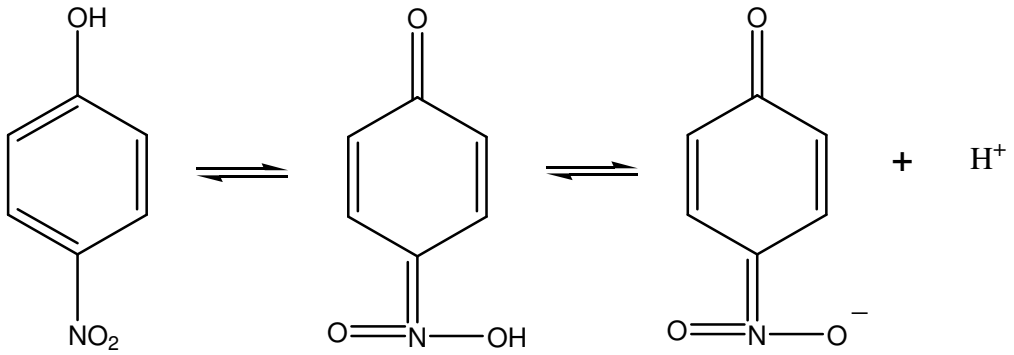
ramsabnis@yahoo.com

Nitro Acid-Base Indicators

COC-2007,
Mumbai, India

ramsabnis@yahoo.com

Colour-change Mechanism



Colourless Acid Form

Yellow Alkaline Form

ramsabnis@yahoo.com

Colour Transition

Indicator	pH Range	Colour Change
Dinitrocresol	2.4-3.8	Colorless to yellow
α-Dinitrophenol	2.0-4.7	Colorless to yellow
β-Dinitrophenol	1.7-4.4	Colorless to yellow
γ-Dinitrophenol	4.0-5.8	Colorless to yellow
ε-Dinitrophenol	3.9-5.9	Colorless to yellow
δ-Dinitrophenol	4.3-6.3	Colorless to yellow
Dinitrothymol	2.2-3.4	Colorless to yellow
Ethyl-bis(2,4-dinitrophenyl)-acetate	7.5-9.1	Colorless to deep blue
Isopicramic acid	4.0-5.6	Rose to yellow
Martius Yellow	2.0-3.2	Colorless to yellow

ramsabnis@yahoo.com

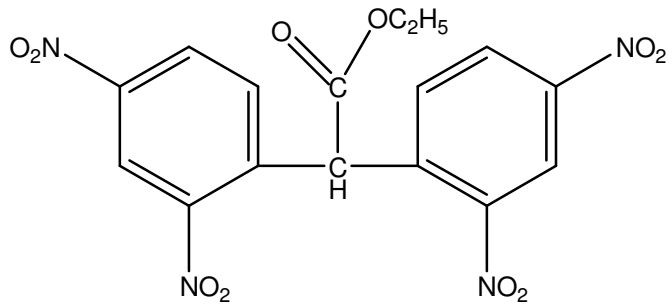
Colour Transition

Indicator	pH Range	Colour Change
Nitramine	10.8-13.0	Colorless to red-brown
p-Nitrobenzhydrazide	8.2-9.5	Colorless to yellow
p-Nitrobenzyl cyanide	11.4-12.9	Yellow to Orange-red
4-Nitrocatechol	3.9-6.3	Straw to lemon yellow
o-Nitrophenol	5.0-7.0	Colorless to yellow
m-Nitrophenol	6.8-8.6	Colorless to yellow
p-Nitrophenol	5.6-7.6	Colorless to yellow
Picric acid	0.0-1.3	Colorless to yellow
Trinitrobenzene	11.5-14.0	Colorless to orange
Trinitrobenzoic Acid	12.0-13.4	Colorless to orange
Trinitrotoluene	11.5-14.0	Colorless to orange

ramsabnis@yahoo.com

Ethyl bis-(2,4-dinitrophenyl)acetate: Applications

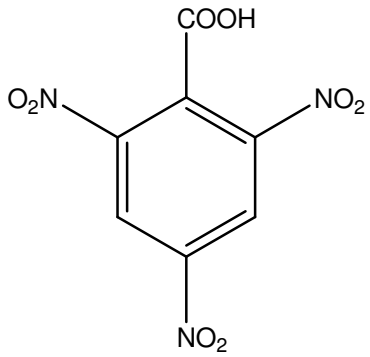
- Imaging materials
- Microcapsule toner
- Electrophotographic toner
- Decoder system
- Inks
- Paints
- Adhesives



ramsabnis@yahoo.com

Trinitrobenzoic acid: Applications

- Explosives
- Liquefied gas fuels
- Energetic materials
- Anti-wear
- Photography
- Photoconductors
- Recording materials
- Inks
- Adhesives



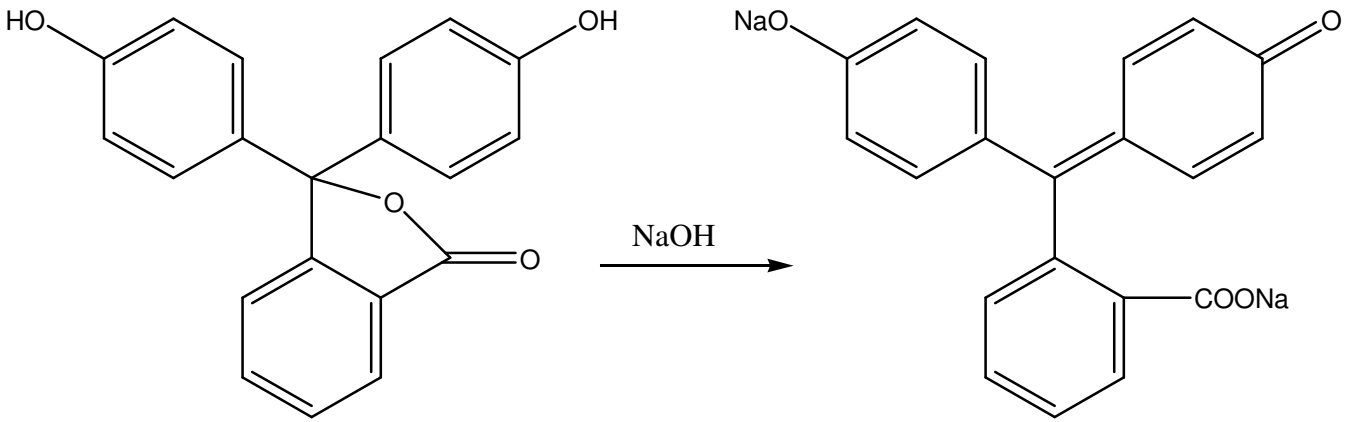
ramsabnis@yahoo.com

Phthalein Acid-Base Indicators

COC-2007,
Mumbai, India

ramsabnis@yahoo.com

Colour-change Mechanism



Colourless Lactone

Acid Form

Highly Coloured

Alkaline Form

Red, Pink, Purple, Violet, Blue, Bluish-Green

Baeyer, A. Ueber die verbindungen der phtalsaure mit den phenolen. *Justus Liebigs Ann. Chem.* **1880**, *202*, 36-140

ramsabnis@yahoo.com

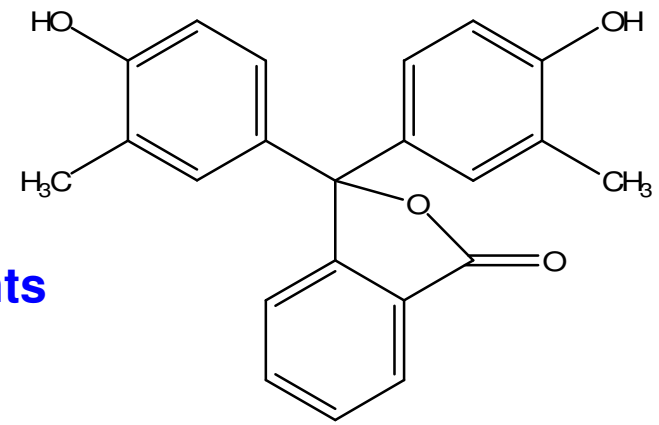
Colour Transition

Indicator	pH Range	Colour Change
Carvacrolphthalein	9.5-10.0	Colorless to blue
o-Cresolphthalein	8.2-9.8	Colorless to red
o-Cresolphthalein complexon	8.2-9.8	Colorless to red
Guaiacolphthalein	8.4-10.2	Colorless to violet-blue
α-Naphtholphthalein	7.3-8.7	Colorless to greenish-blue
Phenolphthalein	8.0-10.0	Colorless to pink
Tetrabromophenolphthalein	7.6-9.4	Colorless to violet
Thymolphthalein	9.3-10.5	Colorless to blue
Xylenolphthalein	9.0-10.5	Colorless to indigo blue

ramsabnis@yahoo.com

o-Cresolphthalein: Applications

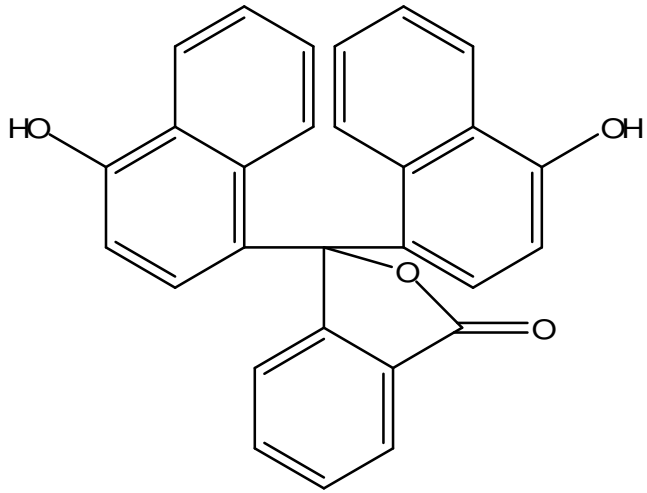
- Sensors
- Display device
- Photoresists
- Recording materials
- Imaging materials
- Authentication system for secure documents
- Decoder system
- Lithium cells
- Inks/Markers
- Toners
- Correction fluid
- Paints
- Adhesives
- Food storage
- Diapers
- Lotion
- Urine analysis test strips
- Drugs
- Blood analysis



ramsabnis@yahoo.com

α-Naphtholphthalein: Applications

- Sensors
- Sol-gel materials
- Thermochromic materials
- Recording materials
- Imaging materials
- Authentication system for secure documents
- Inks/Markers
- Toners
- Paints
- Adhesives
- Rubber
- Lubricants
- Food storage
- Fruits/vegetable packaging
- Detecting viable cells
- Drugs
- Oral hygiene products
- Dental materials



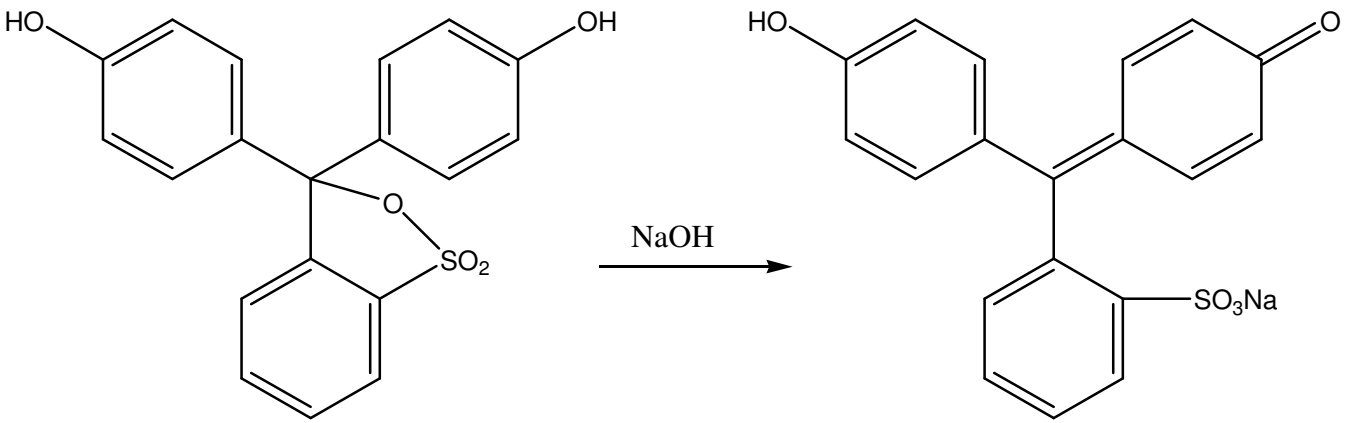
ramsabnis@yahoo.com

Sulfonephthalein Acid-Base Indicators

COC-2007,
Mumbai, India

ramsabnis@yahoo.com

Colour-change Mechanism



Yellow

Acid Form

Highly Coloured

Alkaline Form

ramsabnis@yahoo.com

Colour Transition

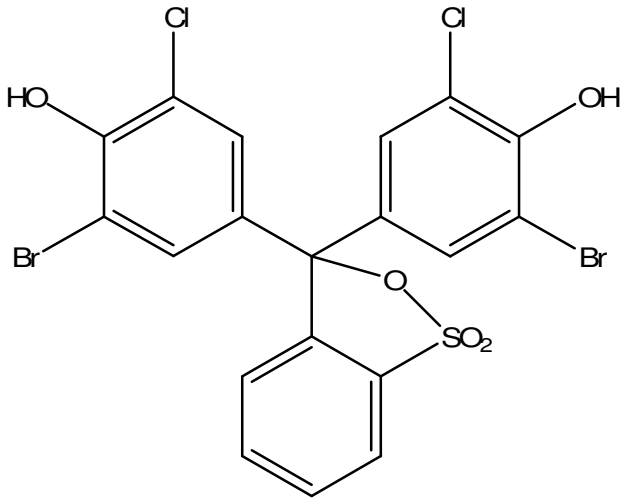
Indicator	pH Range	Colour Change
Bromochlorophenol Blue	3.0-4.6	Yellow to purple
Bromocresol Green	3.8-5.4	Yellow to blue-green
Bromocresol Purple	5.2-6.8	Yellow to purple
Bromophenol Blue	3.0-4.6	Yellow to purple
Bromophenol Red	5.2-6.8	Yellow to red
Bromothymol Blue	6.0-7.6	Yellow to blue
Bromoxylenol Blue	6.0-7.6	Yellow to blue
Chlorophenol Red	4.8-6.4	Yellow to red
m-Cresol Purple	7.4-9.0	Yellow to purple
o-Cresol Red	7.0-8.8	Yellow to reddish-purple
Phenol Red	6.8-8.4	Yellow to red
Thymol Blue	8.0-9.6	Yellow to blue
Xylenol Blue	8.0-9.6	Yellow to blue

COC-2007,
Mumbai, India

ramsabnis@yahoo.com

Bromochlorophenol Blue: Applications

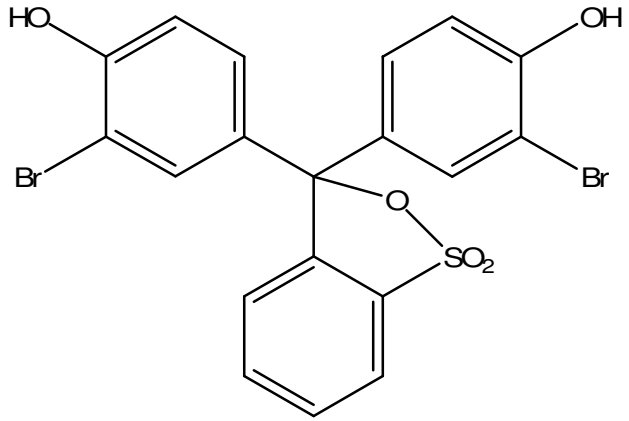
- Display device
- pH sensors
- Inks
- Photoreceptors
- Lithographic plates
- Photographic materials
- Lubricants
- Food shelf life
- Protein assays/detection
- Vaginal infection test



ramsabnis@yahoo.com

Bromophenol Red: Applications

- Sensors
- Sol-gel matrix
- Recording materials
- Thermochromic materials
- Inks
- Paints
- Lubricants
- Soaps
- Cosmetics
- Identifying fresh & stale rice
- Determining acidity in wine
- Food storage
- Determination of bacterial growth
- Anti-amyloid agents
- Evaluating dental caries activity
- Determination of Streptococci in human saliva
- Diagnosis of enterohemorrhagic *Escherichia coli*
- Treatment of acute leukemia



ramsabnis@yahoo.com

Triphenylmethane Acid-Base Indicators

COC-2007,
Mumbai, India

ramsabnis@yahoo.com

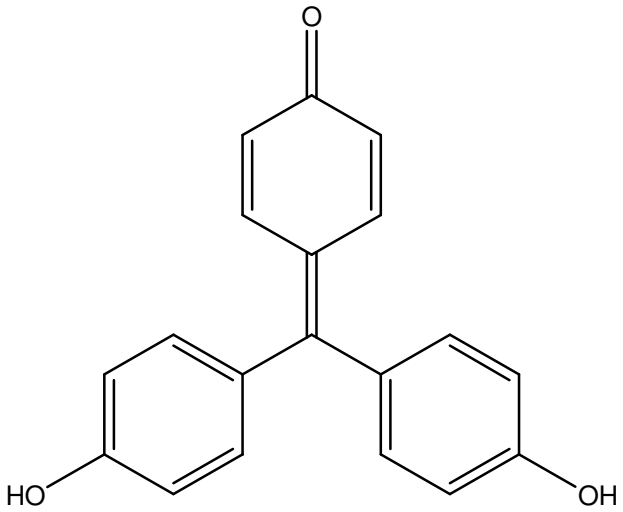
Colour Transition

Indicator	pH Range	Colour Change
Acid Fuchsin	12.0-14.0	Red to colorless
Alkali Blue	9.4-14.0	Blue-violet to red-pink
Aurin	6.6-8.0	Yellow to red
Crystal Violet	0.0-2.0	Yellow to blue-violet
Ethyl Green	0.1-2.3	Yellow to greenish-blue
Ethyl Violet	0.0-3.5	Yellow to blue
Heptamethoxy Red	5.0-7.0	Red to colorless
Hexamethoxy Red	2.6-4.6	Reddish-pink to colorless
Malachite Green	0.0-2.0	Yellow to green
	11.5-14.0	Blue to colorless
Methyl Green	0.1-2.3	Yellow to greenish-blue
Methyl Violet	0.15-3.2	Yellow to violet
Patent Blue V	0.8-3.0	Yellow-orange to deep blue
Pentamethoxy Red	1.2-3.2	Reddish-violet to colorless
Poirrier Blue C 4B	11.0-13.0	Blue to violet-red

ramsabnis@yahoo.com

Aurin: Applications

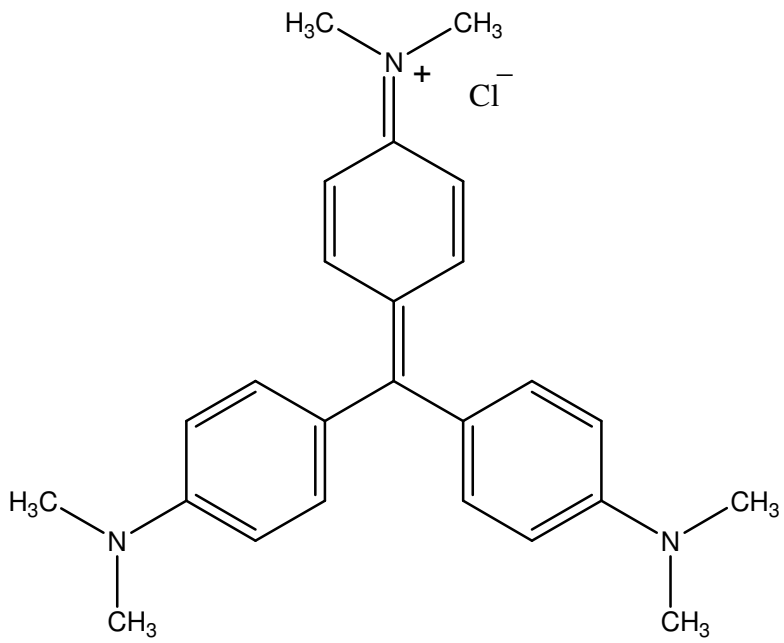
- Antireflective coatings
- Thermochromic materials
- Photoresists
- Film patterning
- Recording materials
- Lithium battery
- Semiconductors
- Inks
- Corrosion inhibitors
- Adhesives
- Drugs
- Detecting viable cells
- Treatment of Alzheimer's disease



ramsabnis@yahoo.com

Crystal Violet: Applications

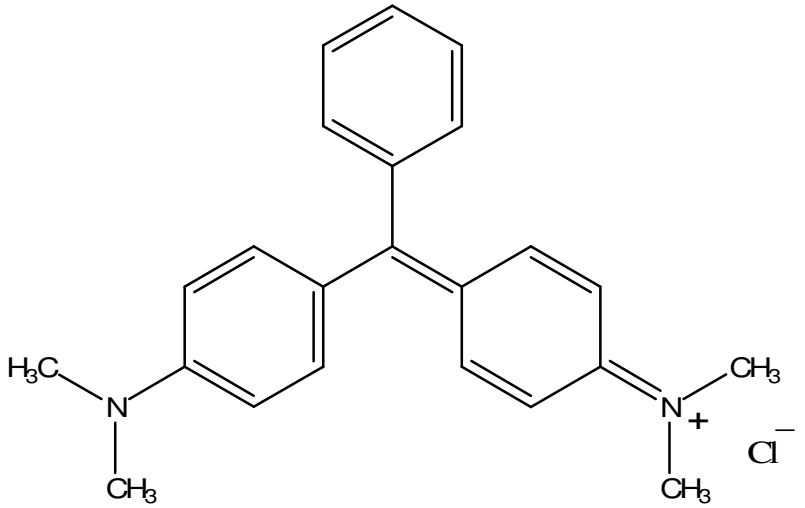
- Photoresists
- Lithographic plates
- Circuit board
- Inks
- Detergents
- Hair dyes
- Shampoo
- Drug screening method
- Bone cement preparation
- Treating microorganism
- Treating hemorrhoids
- Antifungal agent
- Antibacterial agent
- Antimalarial agent
- Dental applications



ramsabnis@yahoo.com

Malachite Green: Applications

- Photoresists
- Color filter
- Sol-gel matrix
- Liquid crystal displays
- Inks
- Herbicides
- Cosmetics
- Identifying mammal genes
- Detecting nucleic acids
- Detecting bacterial growth
- Multidrug resistance inhibitors
- Radiochemotherapy
- Antitumor agent
- Treatment of pulmonary tuberculosis



ramsabnis@yahoo.com

Fluorescent Acid-Base Indicators

COC-2007,
Mumbai, India

ramsabnis@yahoo.com

Miscellaneous Acid-Base Indicators

- Chalcone
- Flavone
- Indigo
- Malein
- Anthraquinone
- Quinoline

ramsabnis@yahoo.com

Colour Transition

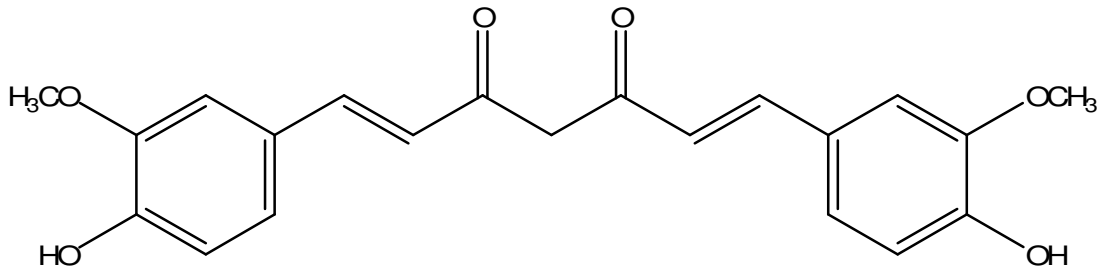
Indicator	pH Range	Colour Change
Curcumin	7.8-9.2	Yellow to red-brown
Hematoxylin	0.0-1.0	Red to yellow
	5.0-6.0	Pale yellow to violet
Indigo Carmine	11.5-14.0	Blue to yellow
Isonitrosothiocamphor	8.6-9.0	Violet to yellow
Neutral Red	6.8-8.0	Red to yellow-orange
Phenolmalein	8.5-10.5	Colorless to straw
Resazurin	3.8-6.5	Orange to purple-violet
Alizarin Red	10.1-12.1	Violet to purple
	5.5-6.8	Yellow to violet
Alizarin Red S	3.7-5.2	Yellow to purple
Pinachrome	5.6-8.0	Colorless to red-violet
Quinaldine Red	1.4-3.2	Colorless to red
Quinoline Blue	7.0-8.0	Colorless to blue-violet

COC-2007,
Mumbai, India

ramsabnis@yahoo.com

Curcumin: Applications

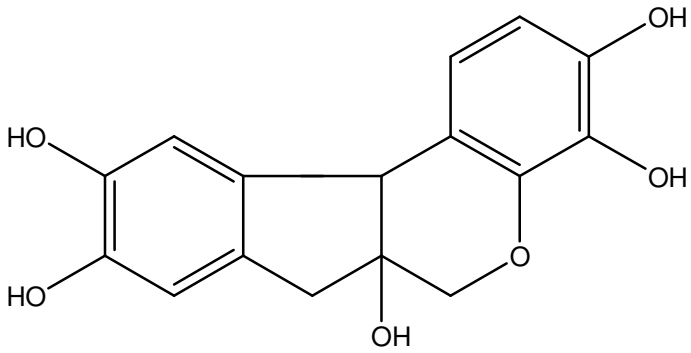
- Cosmetics
- Drug-eluting stents
- Antimicrobial agent
- Antiviral agent
- Antiinflammatory agent
- Treatment of skin diseases
- Treatment of diabetes
- Treatment of obesity
- Treatment of leukemia
- Treatment of Alzheimer's disease
- Treatment of neurofibromas
- Treatment of prostate cancer
- Treatment of coronary restenosis
- Inhibition of formation of skin wrinkles



ramsabnis@yahoo.com

Hematoxylin: Applications

- Plasma displays
- Hair dyes
- Diagnosis of cancer progression
- Diagnosis of cervical disease
- Diagnosis of CNS malfunctions
- Detecting genes
- Detecting breast cancer
- Detecting collagen in a tissue sample
- Detecting apoptosis
- Detecting demyelinating diseases
- Detecting antigens
- Treatment of age-related macular degeneration
- Treatment of burns
- Treatment of prostate cancer
- Treatment of diabetes & obesity
- Treatment of viral diseases
- Treatment of periferal neural & vascular ailments
- Treatment of skin disorders
- Biotechnological applications



ramsabnis@yahoo.com

Major Applications Summary

- Electronics (Displays, color filter, semiconductors, photoresists, nanomaterials, sensors, sol-gel matrix, battery)
- Photography (Recording, copying, imaging materials)
- Inks (Inks, markers, highlighters, toners, correction fluid)
- Paints/Concrete/Rubber/Adhesives/Lubricants
- Detergents/Cleaners/Herbicides/Pesticides/Insecticides
- Personal care and Health/Beauty products (Cosmetics, lipsticks, lotions, hair dyes, soaps, shampoos, toothpaste, diapers, food storage)
- Medical (Assays, detection, diagnosis & treatment of diseases, medical devices, dental/oral products
- Defense/Security/Explosives

ramsabnis@yahoo.com

Literature

- Kolthoff, I. M. *Acid-Base Indicators*; The MacMillan Co.: New York, USA, **1937**.
- Tomicek, O. *Chemical Indicators*; Butterworths Scientific Publications: London, U.K., **1951**.
- Bishop, E. *Indicators*; Pergamon Press: Oxford, U.K., **1972**.

ramsabnis@yahoo.com

Handbook of Acid-Base Indicators: 200+

- Other Names
- CA Index Names
- CAS Registry Number
- Merck Index Number
- Chemical Structure
- Chemical/Dye Class
- Molecular Formula
- Molecular Weight
- pH Range
- Color Change at pH
- pKa
- Physical Form
- Solubility
- UV-Visible Spectrum
- Melting Points
- Boiling Points
- Synthesis
- Applications
- Safety/Toxicity

ramsabnis@yahoo.com

Sabnis, R. W. *Handbook of Acid-Base Indicators*; CRC Press Inc.: Boca Raton, Florida, USA, 2007

ISBN: 9780849382185

ISBN-10: 0849382181

Catalog #: 8218

Publication Date: 10/15/2007

Publisher: CRC Press Inc. (Taylor & Francis Group PLC)

http://www.crcpress.com/

http://www.taylorandfrancis.co.uk/

COC-2007,
Mumbai, India

ramsabnis@yahoo.com

Thank You

- Prof. Dr. V. R. Kanetkar, Head, Dyestuff Technology Department, ICT
- Dr. P. Bineesh, Dyestuff Technology Department, ICT
- Dyestuffs Manufacturers Association of India & Sponsors
- Dyestuff Technology Department, Institute of Chemical Technology, Mumbai
- Convention Committee
- Advisory Committee

ramsabnis@yahoo.com