About OMICS Group

OMICS Group International is an amalgamation of Open Access publications and worldwide international science conferences and events. Established in the year 2007 with the sole aim of making the information on Sciences and technology 'Open Access', OMICS Group publishes 400 online open access scholarly journals in all aspects of Science, Engineering, Management and Technology journals. OMICS Group has been instrumental in taking the knowledge on Science & technology to the doorsteps of ordinary men and women. Research Scholars, Students, Libraries, Educational Institutions, Research centers and the industry are main stakeholders that benefitted greatly from this knowledge dissemination. OMICS Group also organizes 300 International conferences annually across the globe, where knowledge transfer takes place through debates, round table discussions, poster presentations, workshops, symposia and exhibitions.

About OMICS Group Conferences

OMICS Group International is a pioneer and leading science event organizer, which publishes around 400 open access journals and conducts over 300 Medical, Clinical, Engineering, Life Sciences, Phrama scientific conferences all over the globe annually with the support of more than 1000 scientific associations and 30,000 editorial board members and 3.5 million followers to its credit.

OMICS Group has organized 500 conferences, workshops and national symposiums across the major cities including San Francisco, Las Vegas, San Antonio, Omaha, Orlando, Raleigh, Santa Clara, Chicago, Philadelphia, Baltimore, United Kingdom, Valencia, Dubai, Beijing, Hyderabad, Bengaluru and Mumbai.

Novel Organic Transformations in Aqueous Media



Dr J S Yadav FNA, FTWAS

CSIR-Bhatnagar Fellow and Former Director

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Humanity's Top Ten Problems for next 50 years

1. ENERGY
2. WATER
3. FOOD
4. ENVIRONMENT
5. POVERTY
6. TERRORISM & WAR
7. DISEASE
8. EDUCATION
9. DEMOCRACY
10. POPULATION



2004	6.5	Billion People
2050	~ 10	Billion People

..... R. Smalley, Rice Univ.



ELECTRONICS

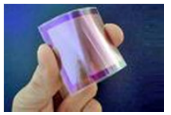
Biomed. & HEALTH



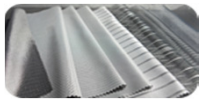
AEROSPACE



Energy + Nano



TEXTILE



Nanotechnology

Biotechnology



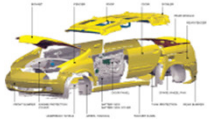
ENGINEERING



TRANSPORTS

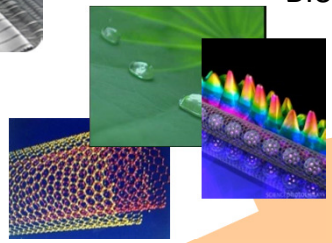


New materials
Catalysts



Aero





Automotives



Process





DRUG DISCOVERY

Technological Advancement

Climate Change

Global Warming

Pollution

Human Health



SAFETY & ENVIRONMENTAL CONCERNS

Source of pictures: www.googleimages.com

CHEMISTRY

- Pharmaceuticals that have improved health and extended life
- Fertilizers that have greatly increased food productivity
- Semiconductors that have made possible computers and other modern electronic devices

- Pollutants
- Toxic substances
- Nonbiodegradable plastic containers

These have resulted in harm to the environment

Need for Green and sustainable chemistry

Prevent wastes

Renewable materials

Omit derivatization steps

Degradable chemical products

Use safe synthetic methods

Catalytic reagents

Temperature, pressure ambient

In-process monitoring

Very few auxiliary substances

E-factor, maximize feed in product

Low toxicity of chemical products

Yes, it is safe

NATURE |Vol 450| 6 December 2007



http://www.scienceathartridge.org



Green Chemistry @ IICT



- Greener Solvents- Water/ionic liquid
- Clean Synthesis
- Atom Economy
- **Biocatalysis**
- Phase Transfer catalysis
- Zeolites
- Photochemistry
- Microwave Chemistry
- Molecular Modelling & Bio-informatics
- **Enzymatic Degumming of Oils**
- Recycling of chemicals

- Solar Energy-dye solar cell/organic
- Biomemitic nanomaterials
- Renewable Resource based polymers
- Bio-polymers
- Energy from waste
- Eco-friendly coatings

Cleaner Reaction Media ("Green Solvents")

- Supercritical fluids
- Ionic liquids
- **Water (Enzymatic/Metal catalyzed reactions)**
- Perfluorinated hydrocarbons
- No solvent at all ! (Microwave irradiation etc)
- **Biotransformations**

Problems Associated with Enzymatic Reactions

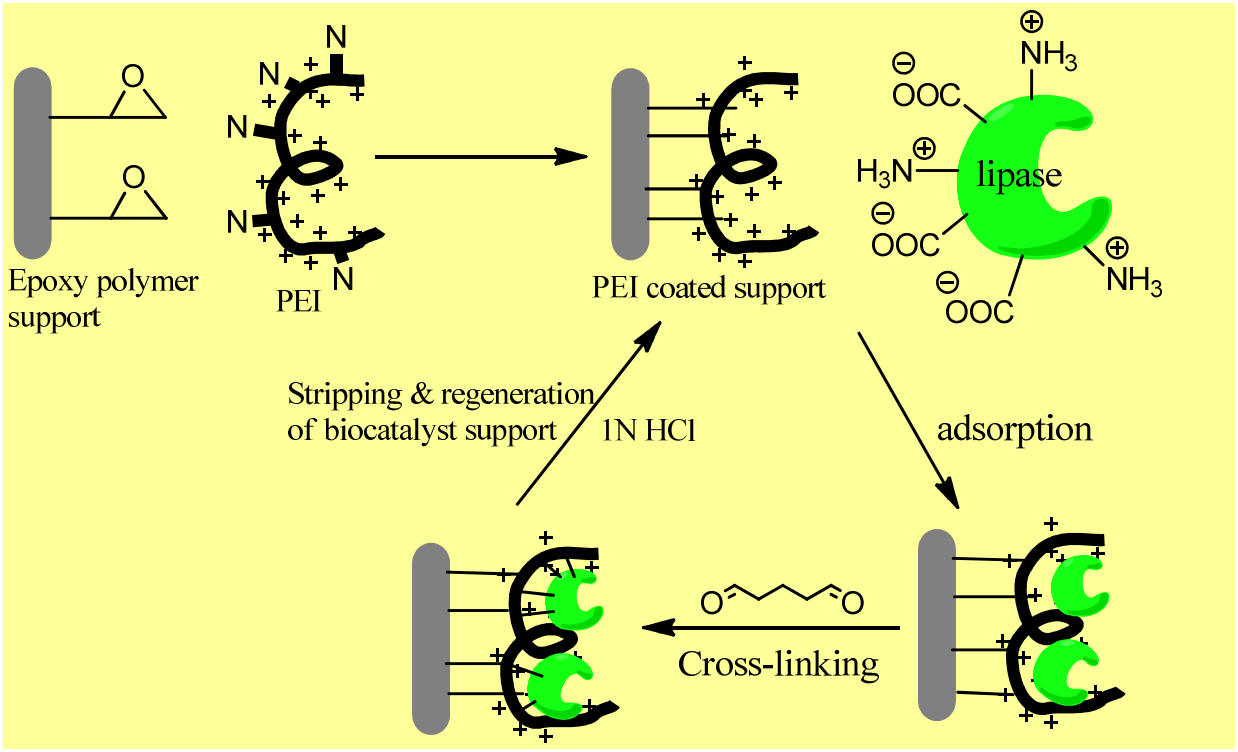
1. Enzyme cost and stability
2. Substrate solubility and product isolation

Solution for 1: Enzyme Immobilization

- Attach the enzyme to a solid support and reuse after the reaction

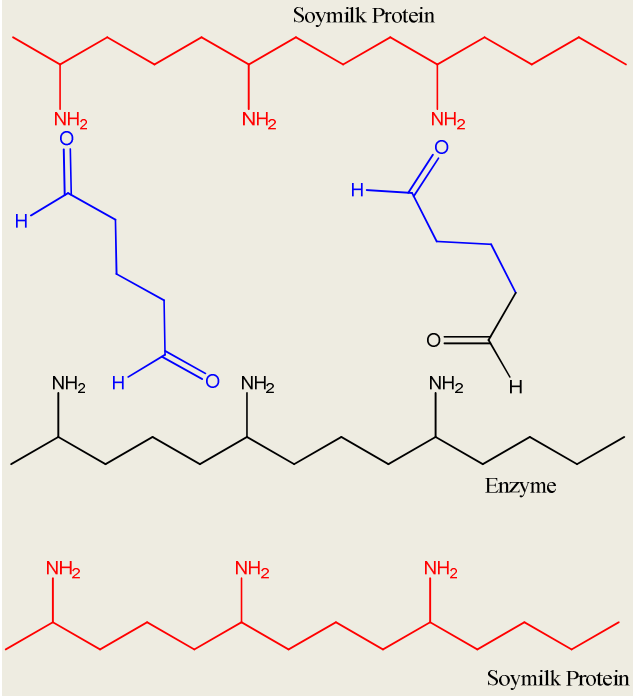
Solution for 2: Enzyme works in organic solvent as well

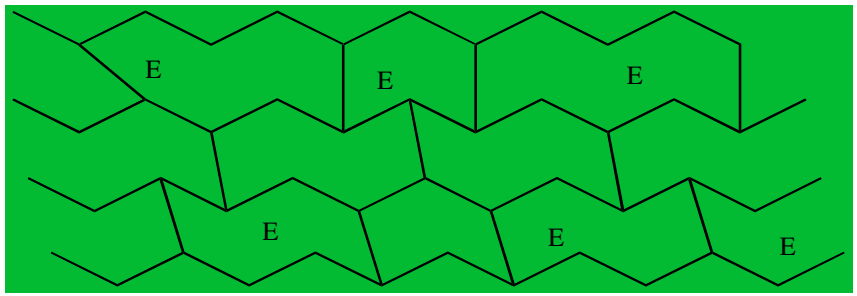
Reusable Polymer Supports



Recovery of enzyme activity > 90%.

Cross-linked Enzyme Aggregates (CLEAs)

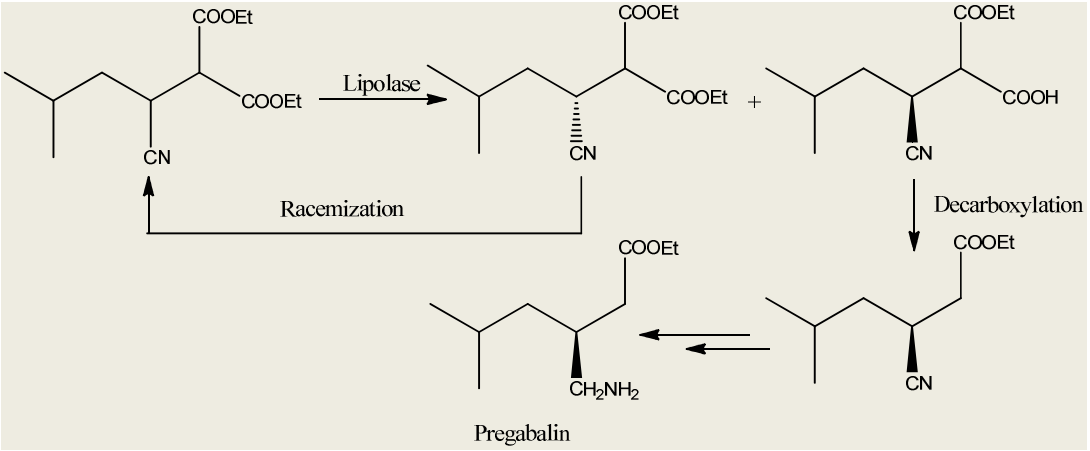




Recovery of enzyme activity 30-35%. Can work in organic solvent as well as in water.

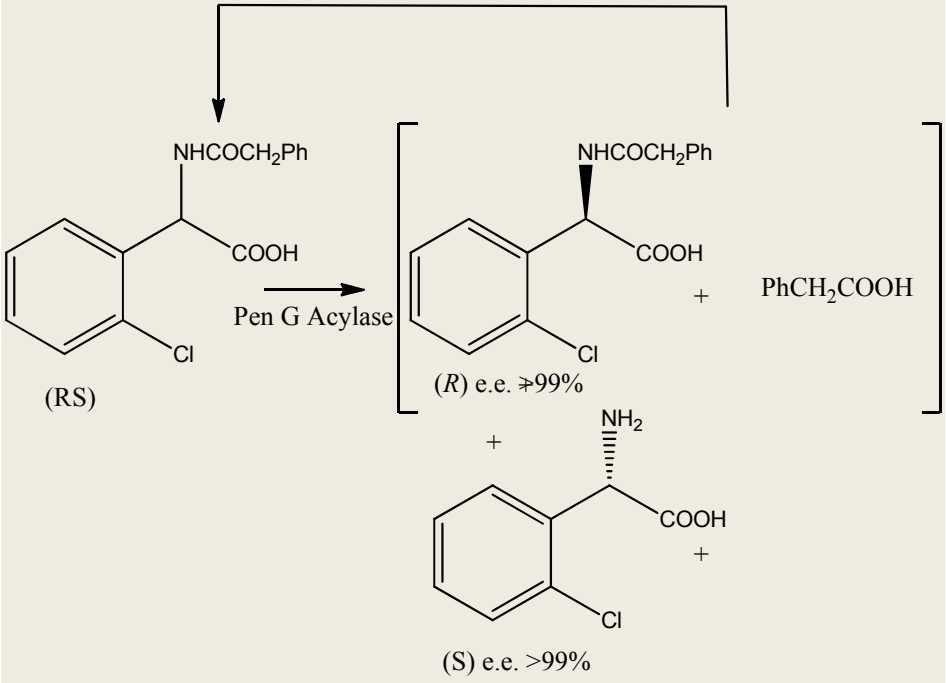
Applications

Resolution of 3-cyano-5-methylhexanoic acid ethyl ester (Pregabalin intermediate, drug for Epilepsi) using immobilized lipase from *Thermomyces lanuginosus* (Lipolase)

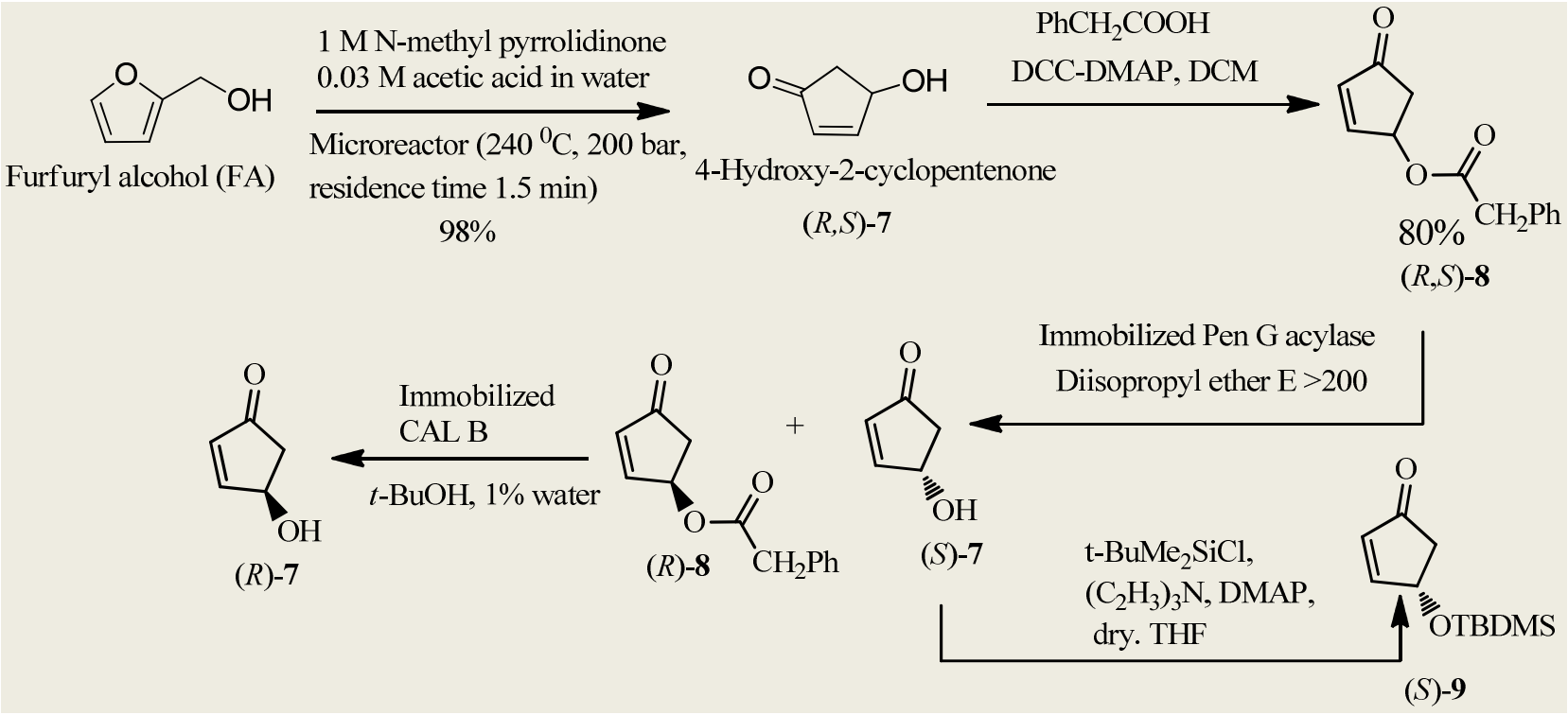


Resolution of racemic 2-chlorophenyl glycine

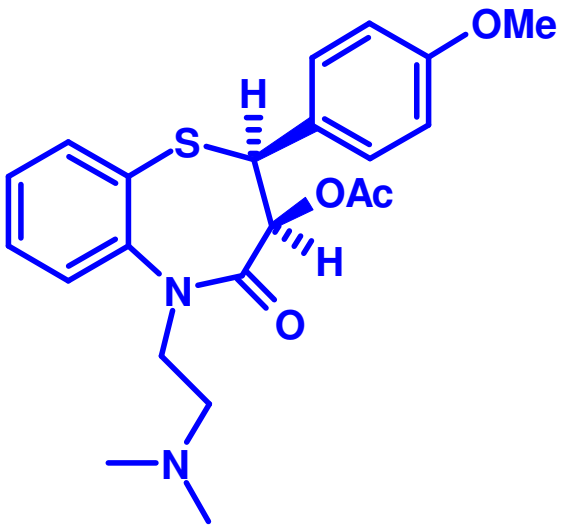
- (S)-Acid is important intermediate for Clopidogrel (Oral antiplatelet agent)



Resolution of 4-hydroxy-2-cyclopentenone



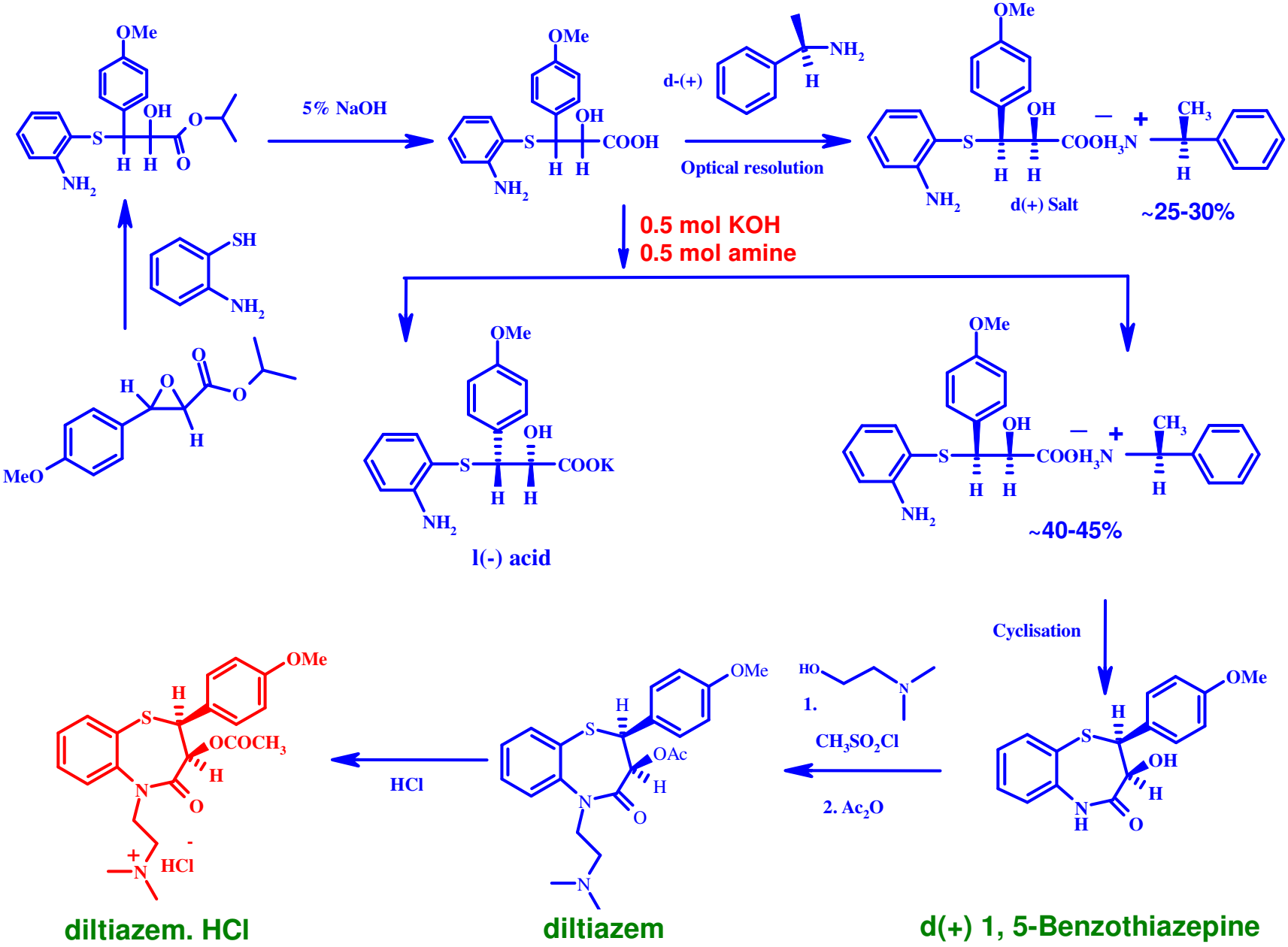
Diltiazem



Diltiazem

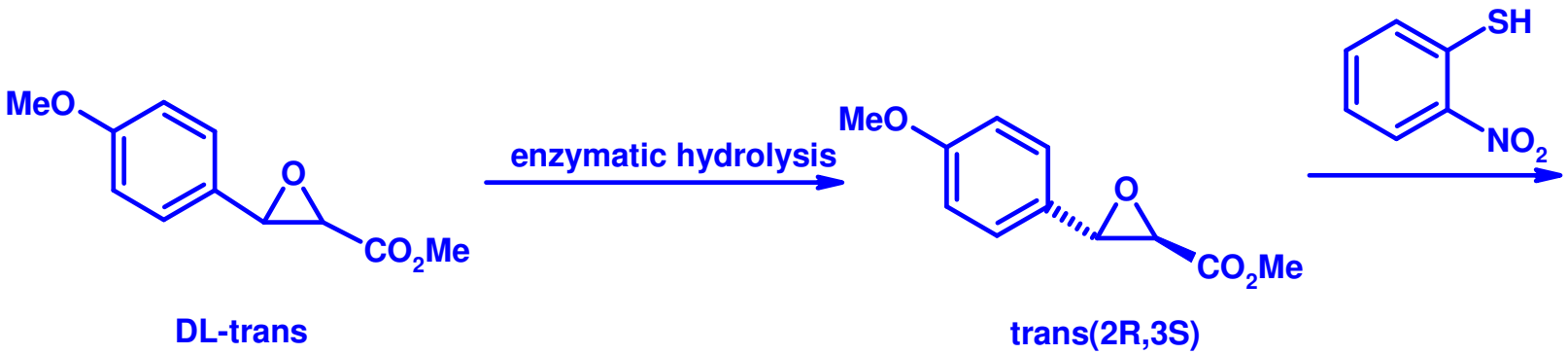
- **Diltiazem is a member of the group of drugs known as benzothiapines, which are a class of calcium channel blockers.**
- **Used in the treatment of hypertension, angina pectoris and some types of arrhythmia**
- **It is a potent vasodilator.**

IICT process for Diltiazem



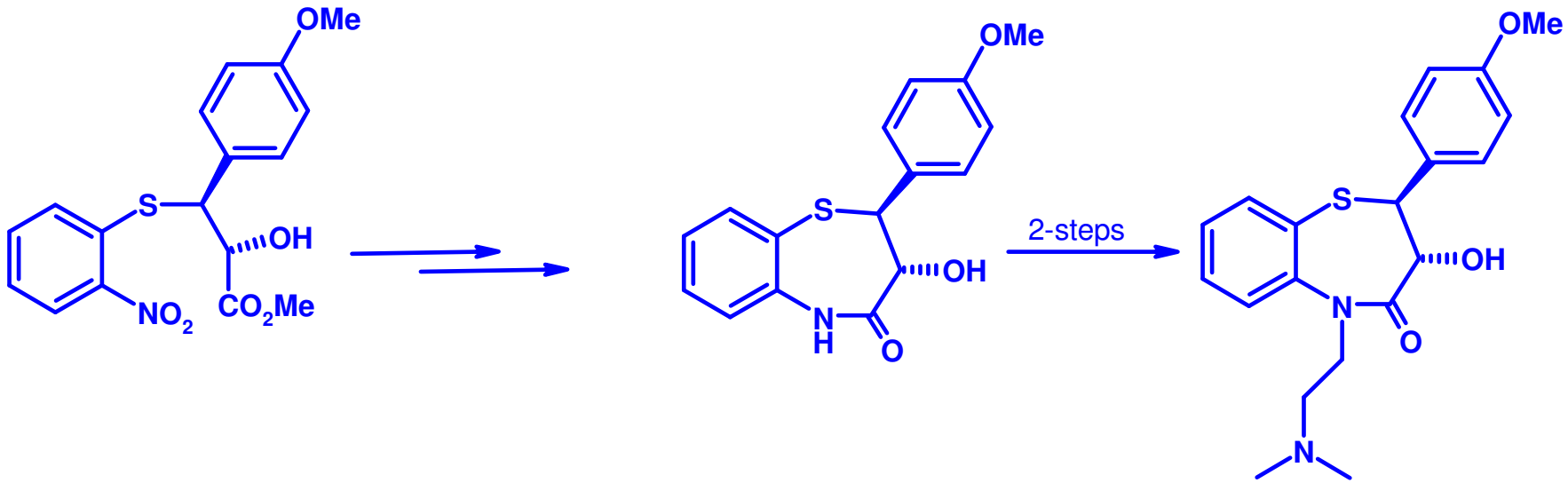
Yadav *et al* Patent no:US6130352

Industrial process for Diltiazem

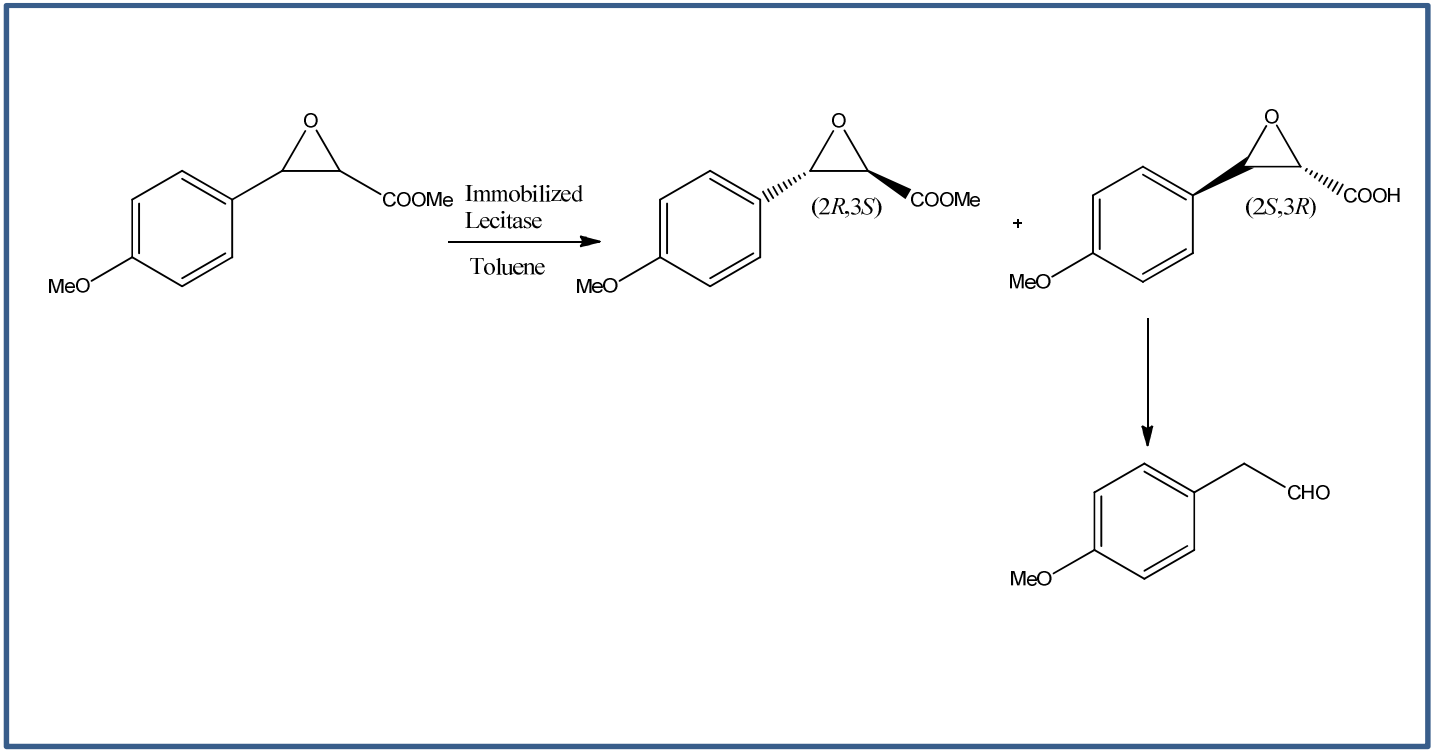


DL-trans

trans(2R,3S)



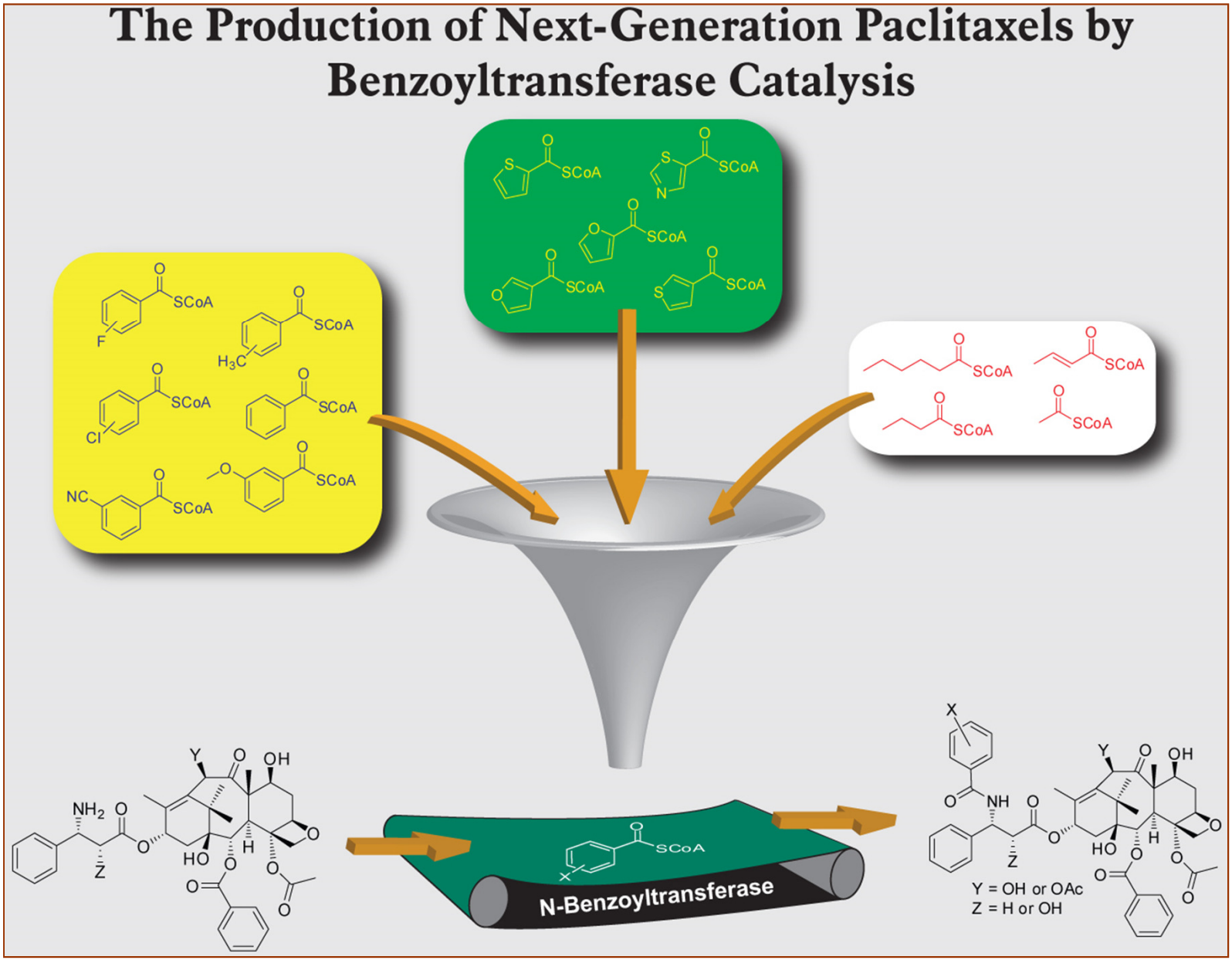
Resolution of Glycidate Esters



Biotransformation & Biocatalysis

Some selected milestones of industrially relevant biotransformation and biocatalytic processes

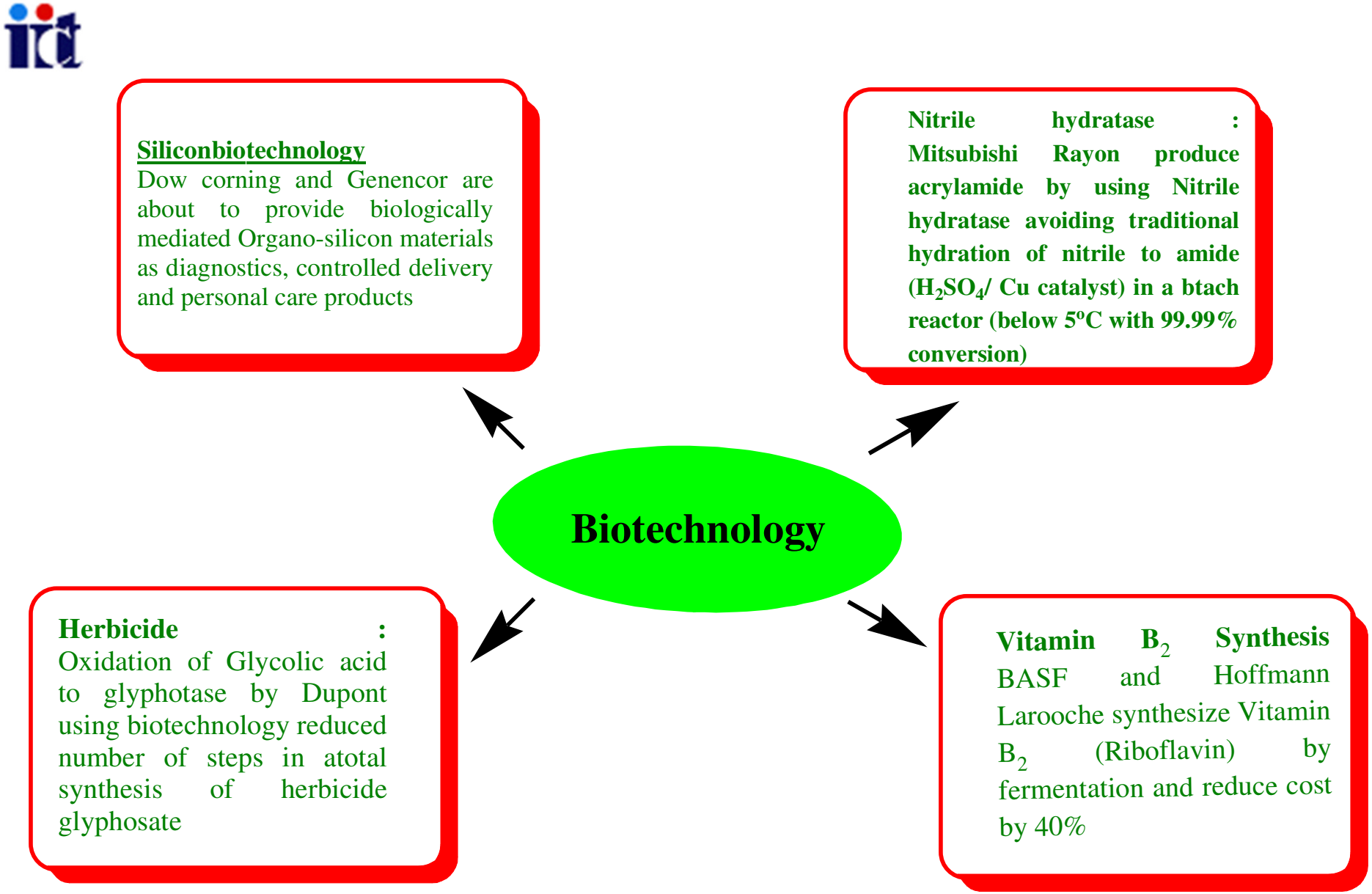
year	process
5000 BC	Vinegar production
800 BC	Casein hydrolysis with chymosin for cheese production
1670	"Orlean" process for the industrial bio-oxidation of ethanol to acetic acid
1680	Antoni van Leeuwenhoek first to see microorganisms with his microscope.
1897	E. Buchner discovers yeast enzymes converting sugar into alcohol
1934	Regioselective biooxidation of sorbite to sorbose for the Reichstein Vitamin C synthesis
1940	Sucrose inversion using an invertase
1950	Bioconversion of steroids
1970	Hydrolysis of penicillin to 6-aminopenicillanic acid
1973	First successful genetic engineering experiments
1974	Glucose to fructose isomerisation with immobilized glucose isomerase
1985	Enzymatic process for the production of acrylamide
1990	Hydrolysis by protease (trypsin) of porcine insuline to human insuline
1995	3000 ton pa plant for the biotransformation of nicotinonitrile to nicotinamide



Source; http://news.msu.edu/media

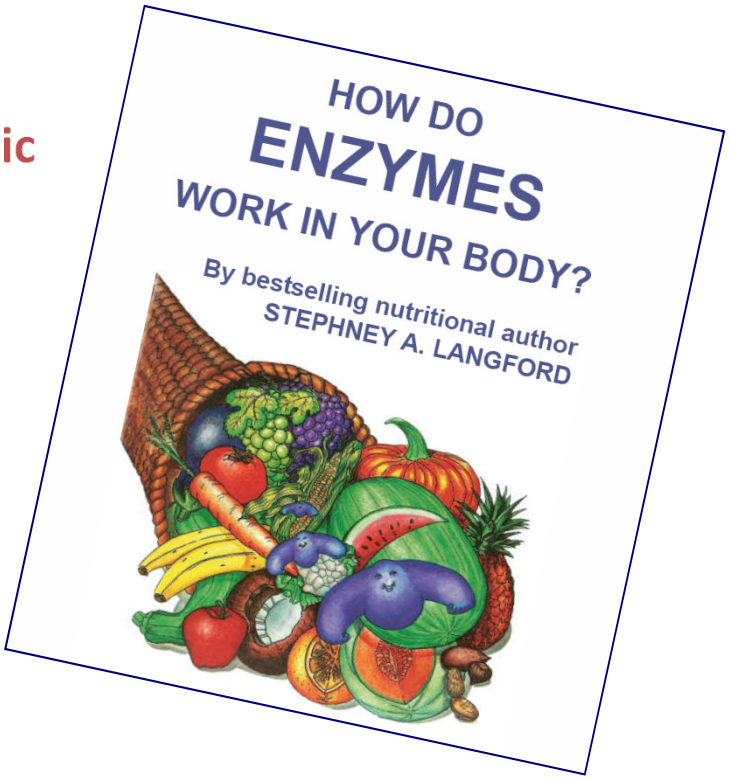
ENZYMATIC TRANSFORMATIONS




Siliconbiotechnology
Dow corning and Genencor are about to provide biologically mediated Organo-silicon materials as diagnostics, controlled delivery and personal care products
Nitrile hydratase : Mitsubishi Rayon produce acrylamide by using Nitrile hydratase avoiding traditional hydration of nitrile to amide (H_2SO_4/ Cu catalyst) in a btach reactor (below 5°C with 99.99% conversion)
Biotechnology
Herbicide : Oxidation of Glycolic acid to glyphotase by Dupont using biotechnology reduced number of steps in atotal synthesis of herbicide glyphosate
Vitamin B_2 Synthesis BASF and Hoffmann Larooche synthesize Vitamin B_2 (Riboflavin) by fermentation and reduce cost by 40%

USING PLANTS FOR GREEN CHEMISTRY

- In developing countries, issues with synthetic reagents and solvents involve high cost, delays in delivery, customs duty and taxes, agent fees
- What is the potential to use local plants as sources of needed enzymes for synthetic organic transformations?
- What are the cheapest, readily available plants? - **Vegetables**



HISTORICAL OVERVIEW



1991 Naoshima and Akakabe showed that immobilized cells of *Daucus carota* reduced acetophenone in yield of 54% after five days with 99% ee

1996 Chadha and co-workers found that 2-oxo- 4-phenylbutanoic acid ethyl ester was reduced by *D. carota* cell cultures in 100% yield and >99% ee after 10 days

Drawback: Requires cell preparations



AQUEOUS CARROT PREPARATIONS - I

- **2000 Marioni and co-workers:**

  Freshly cut carrot root reduced (±)-2-methyl-cyclohexanone in 48 hr to a 1:1 mixture of the (1*S*,2*R*)- and (1*S*,2*S*)-2-methyl cyclohexanols in 99% ee and in 75% yield

- **2001 Yadav and co-workers:**

  (*R*)-2-Azido-1-arylethanols could be produced from the corresponding azido-ketone in 92% yield and 99% ee in 2 days

AQUEOUS CARROT PREPARATIONS - II

- A new reagent for aromatic ketone reduction
- Are there other, better, cheaper, more flexible possibilities?

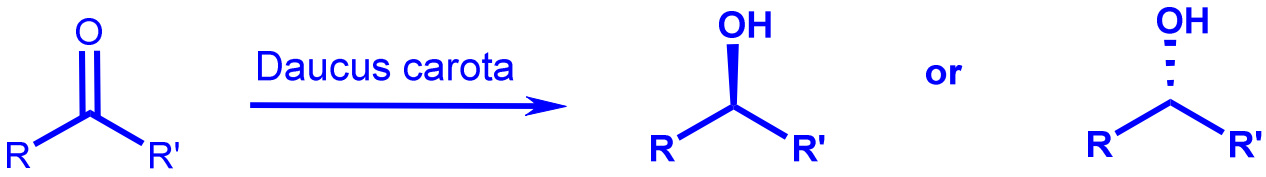


NOVEL ENZYMATIC TRANSFORMATIONS USING DAUCUS CAROTA

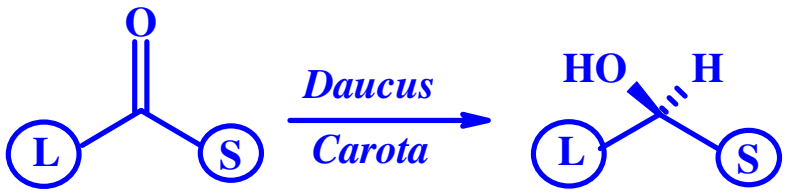


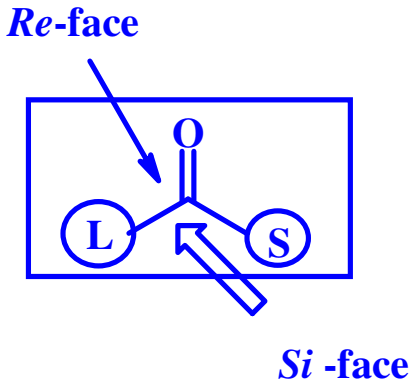
- ❑ **Operational simplicity**
- ❑ **Easy isolation of reaction products**
- ❑ **Inexpensive & readily available biomaterial**
- ❑ **Mild reaction conditions**
- ❑ **High yield**
- ❑ **Good Enantioselectivity**
- ❑ **Water is used as solvent**

REDUCTION OF PROCHIRAL KETONES



Aliphatic & aromatic ketones, cyclic ketones, β-ketoesters, azidoketones.

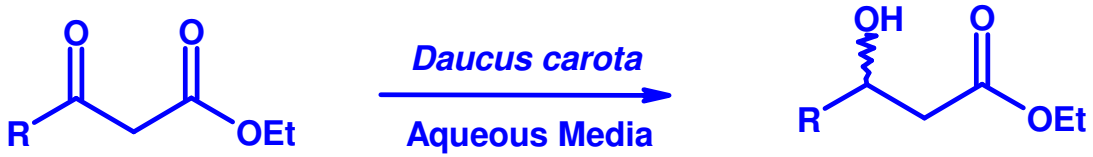




Yadav & Nanda et. al, *J. Org. Chem.* 2002, *67*, 3900

Hydrogen attack from Re-face

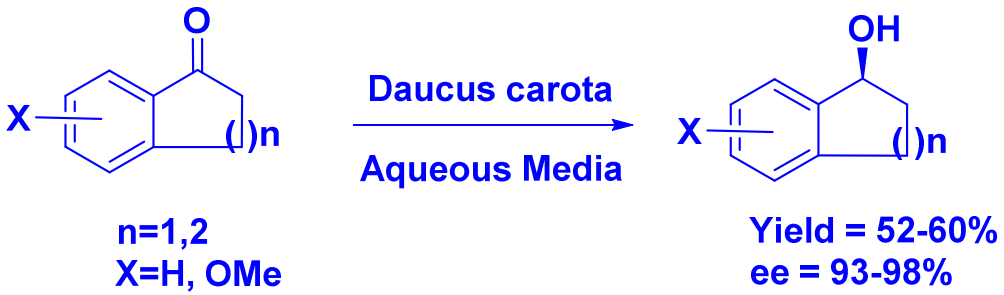
REDUCTION OF β-KETO ESTERS



Yield=50-77%
Ee=78-95%

Entry	Compound	Time of conversion (h)	Yield (%)	ee (%)	Configu-ration
1	Ethylacetoacetate	58	58	95	*S*
2	Ethyl-4-chloro-3-oxobutanoate	60	50	90	*S*
3	Ethyl-4-bromo-3-oxobutanoate	62	53	95	*S*
4	Ethyl-4-azido-3-oxobutanoate	65	68	90	*R*
5	Ethyl-4, 4,4 trifluoro-3-oxobutanoate	56	72	78	*R*

REDUCTION OF CYCLIC KETONES



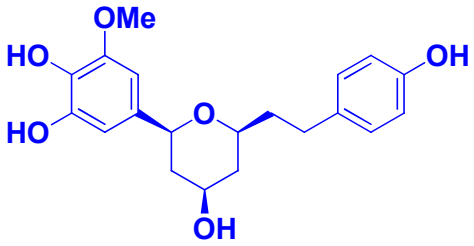
n=1,2
X=H, OMe

Yield = 52-60%
ee = 93-98%

Entry	Compound	Time of Conversion (h)	Yield (%)	Ee (%)	Configuration
1	1-Tetralone	70	52	96	*S*
2	2-Tetralone	72	58	95	*S*
3	6-Methoxy-1-tetralone	69	60	93	*S*
4	1-Indalone	78	57	98	*S*

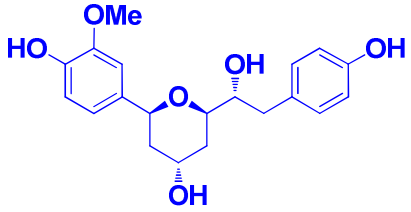
Journal of Organic Chemistry , 2002, 67, 3900

Natural Products with Tetrahydropyran Core



Diarylheptanoid (anti-oxidant, anti-tubulin)

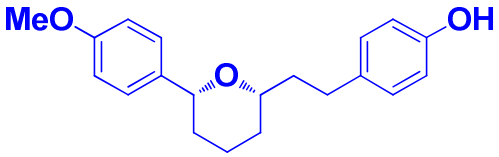
Isolated from Zingiber Officinale (TL 2009, 50, 3686)



Rhoiptelol B

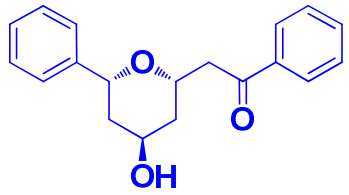
Regulator of NO and TNF-α production (Synthesis 2010(24): 4300)

Isolated from Rhoiptelol Chiliantha (Phytochemistry, 43, 1996, 1049)



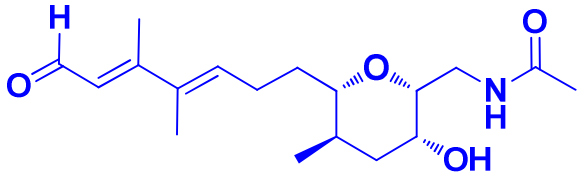
Centrolobine (OL 2002, 4, 1723)

Isolated from Centrolobium robustum (anti-biotic)



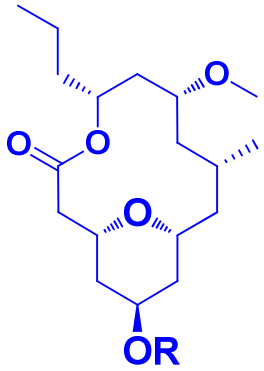
Diospongin A (Synlett 2007, 2046)

Isolated from Dioscoria spongiosa (anti-osteoporotic)



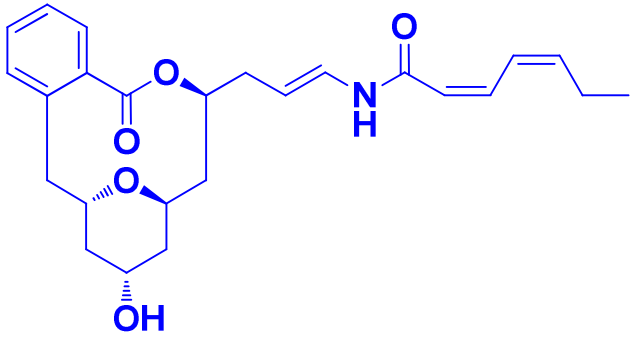
Brevisamide (OL 2009, 11, 3950)

Natural Products with Tetrahydropyran Skeleton



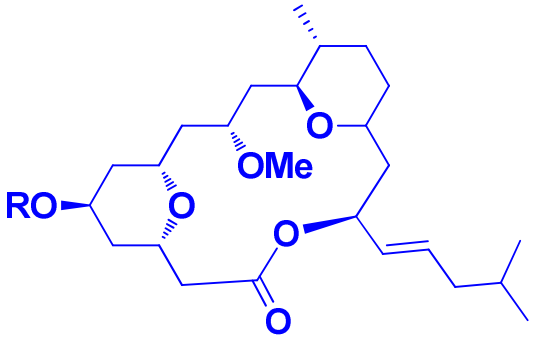
Neopeltolide (J Nat Prod. 2007, 70, 412)

Isolated from Neopeltidae (anti-cancer)



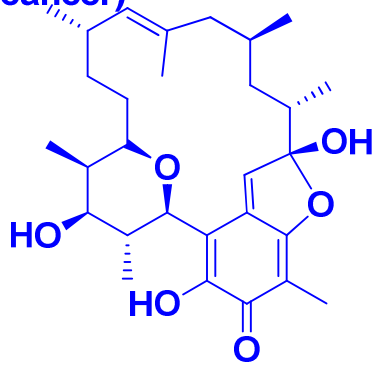
Apicularin (OL 2010, 12, 4160)

(anti-cancer)



Leucascandrolide A (Helvetic Chimica Acta 1996, 79, 51)

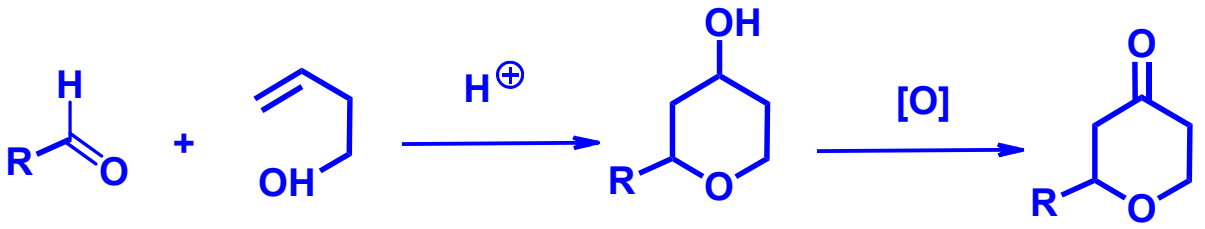
Antiproliferative marine natural product

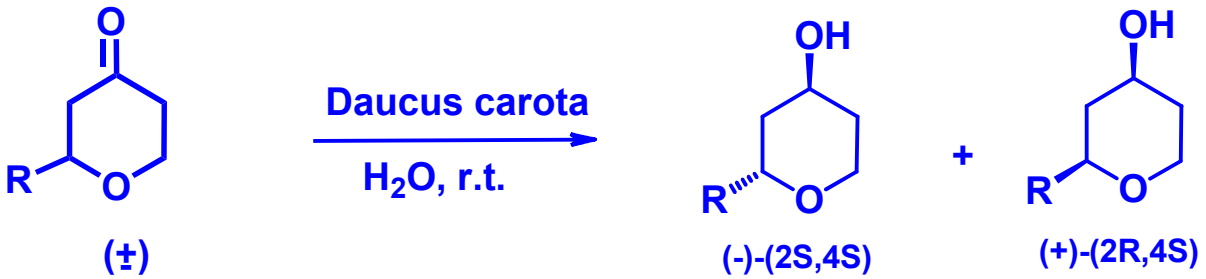


Kendomycin (JACS 2008, 130, 177)

Anti-biotic

Enantioselective Reduction of 2-Substituted Tetrahydropyran-4-ones using *Daucus Carota*





(±)

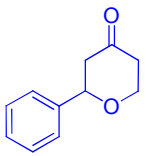
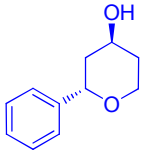
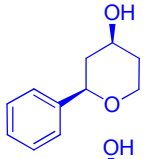
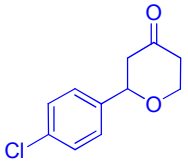
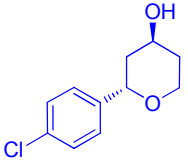
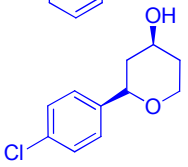
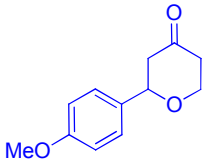
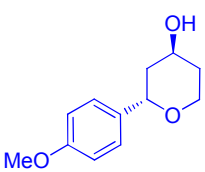
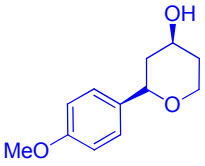
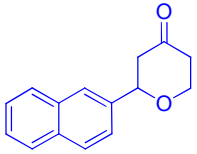
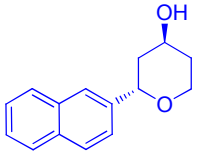
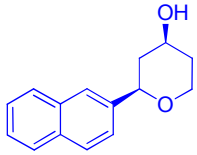
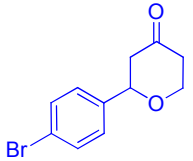
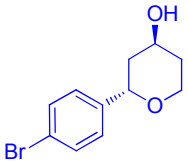
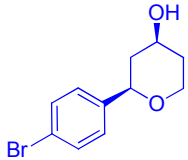
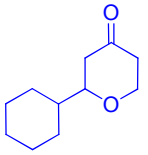
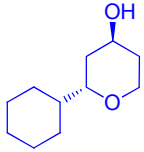
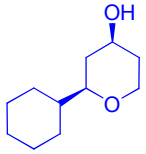
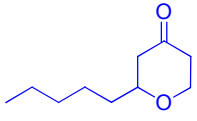
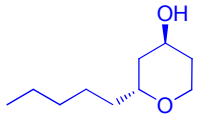
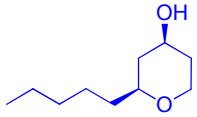
(-)-(2S,4S)

(+)-(2R,4S)

R = aryl or cyclohexyl

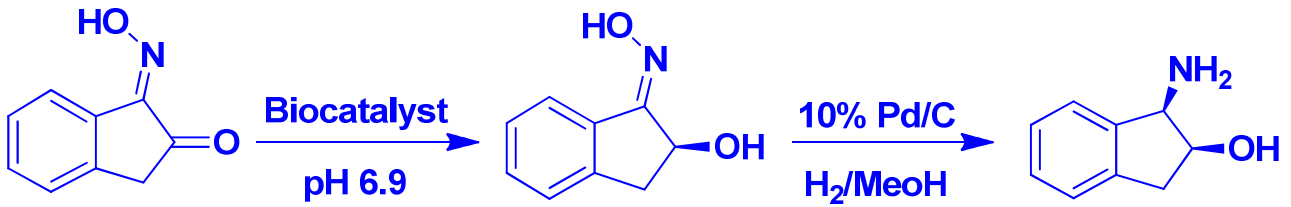
Tetrahedron Lett. 2008, *49*, 2768

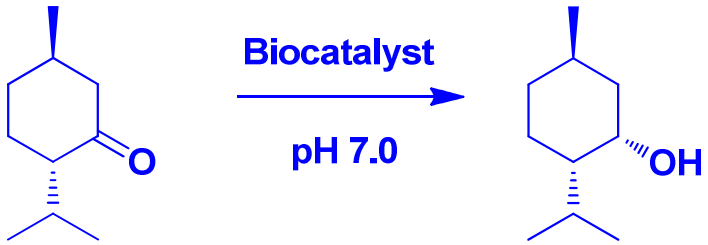
Reduction of Tetrahydropyranones using *Daucus Carota*

Entry	Substrate	Alcohol	$[\alpha]_D^{25}$	ee(%)c	Alcohol	$[\alpha]_D^{25}$	ee(%)	Time (h)	Yield(%
a			-18.8	94		15.6	92	24.0	92
b			-14.7	90		25.3	86	26.0	94
c			-16.0	87		17.8	85	30.0	90
d			-27.9	94		25.6	89	29.0	90
e			-18.6	90		16.6	83	24.0	92
f			-9.9	88		9.6	86	32.0	88
g			-8.6	92		6.6	87	38.0	85

Bioreduction of Aromatic Prochiral Ketones by *Daucus Carota*

Preparation of cis-Aminoindanol

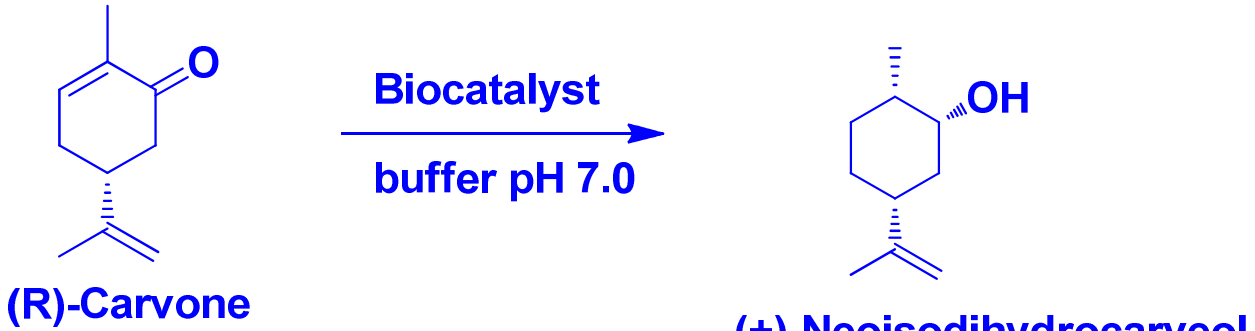




Menthone (+)-Neomenthol

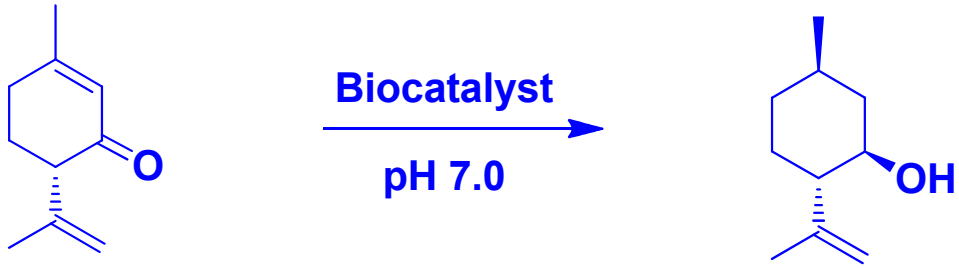
Tetrahedron Asym, 2007, *18*, 717

Reduction of *mono*-Terpenoid Ketones by *Daucus Carota*



(R)-Carvone

(+)-Neoisodihydrocarveol

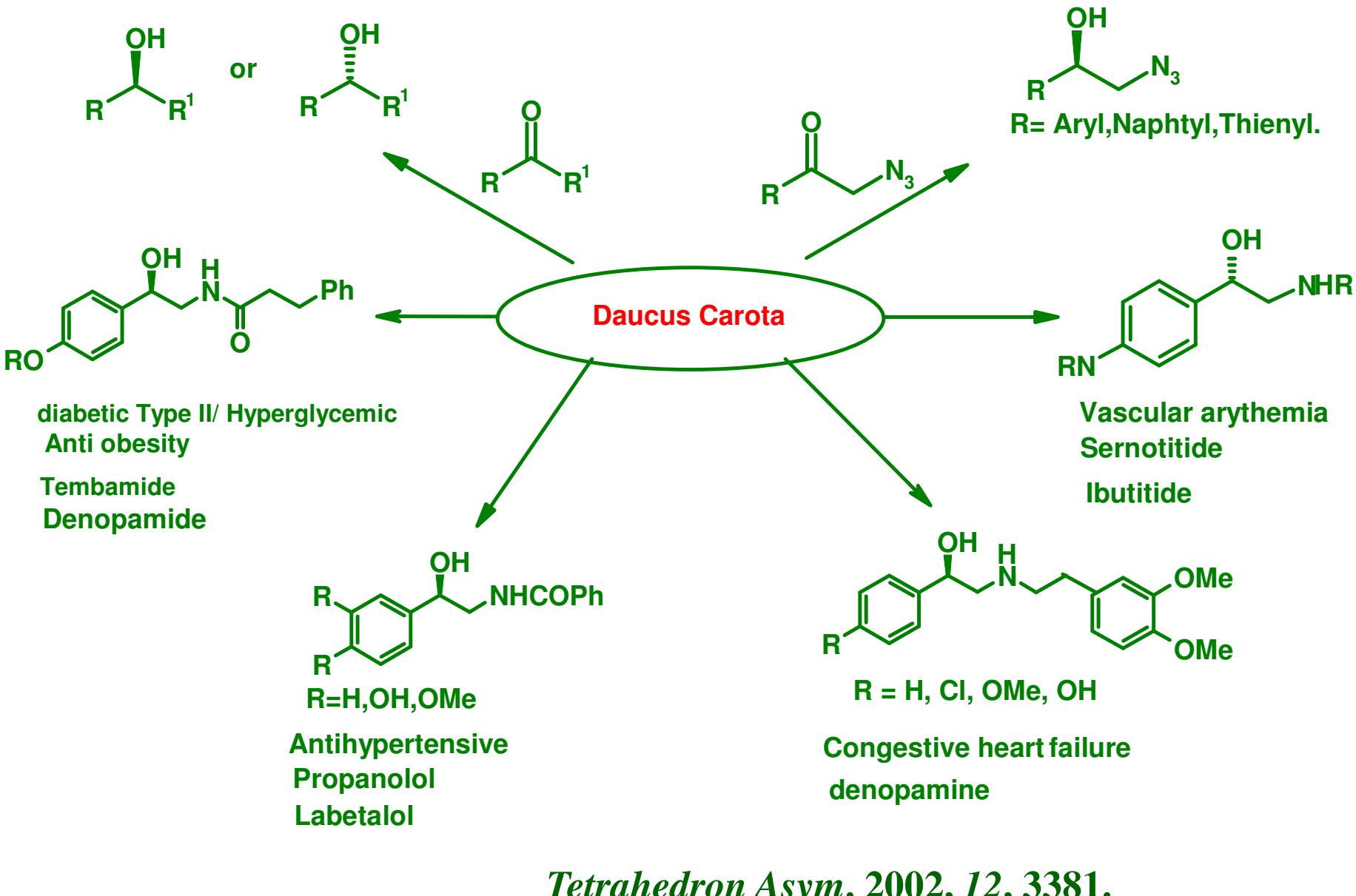


(S)-Isopiperitenone

(-)-Isopulegol

Tetrahedron Asym. 2007, *18*, 717

Daucus Carota Promoted Reduction of Ketones



Tetrahedron Asym. 2002, *12*, 3381.

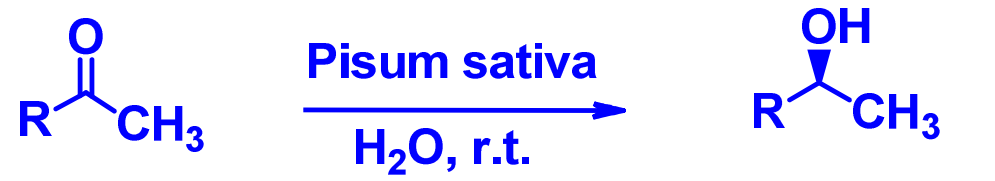


PISUM SATIVA (GREEN PEAS)



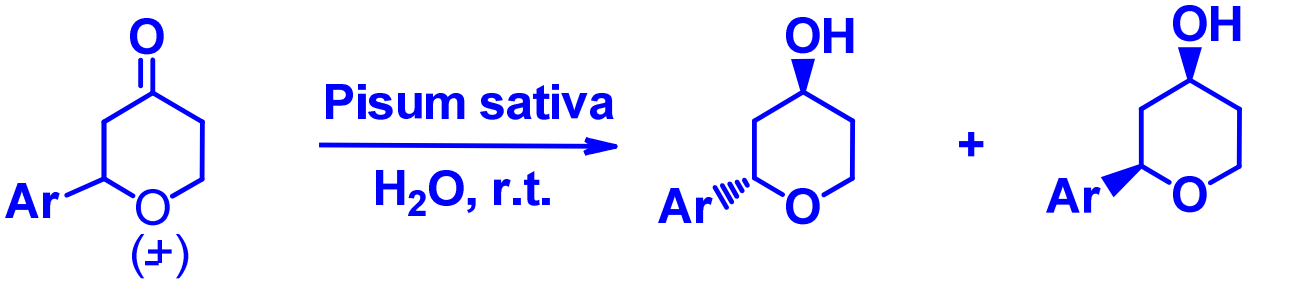


Green Protocol for Enantioselective Reduction of Ketones using Sprouted *Pisum Sativa*



R = aryl or alkyl

(S)-Isomer

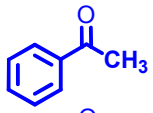
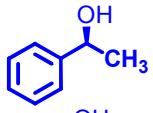
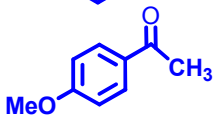
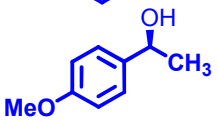
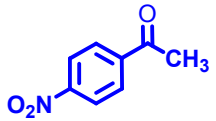
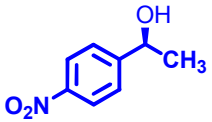
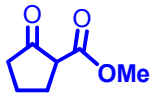
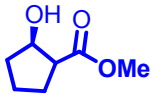
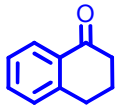
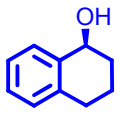
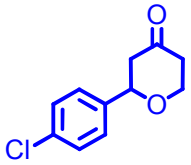
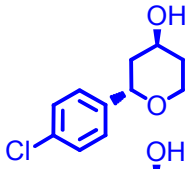
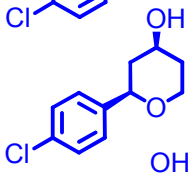
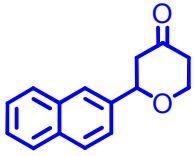
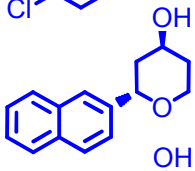
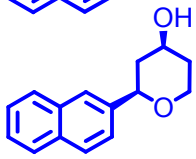


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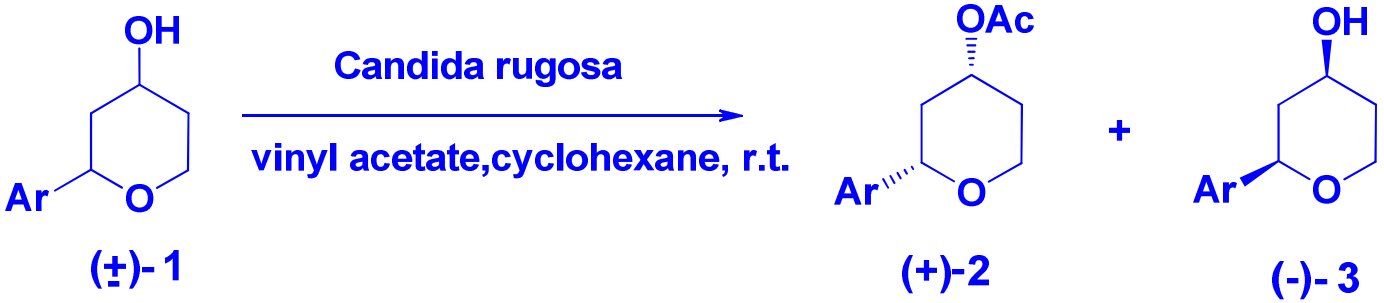
(+)-(2R,4S)

Synthesis 2009, 1881

Reduction of Ketones using Sprouted *Pisum Sativa*

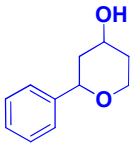
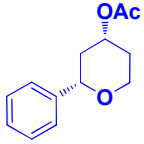
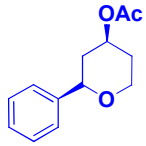
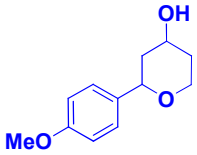
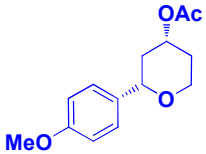
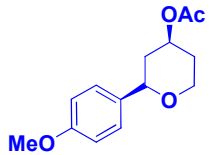
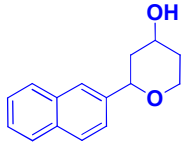
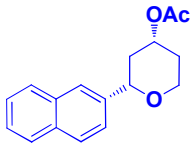
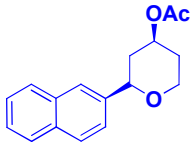
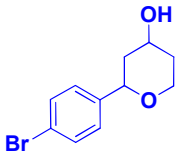
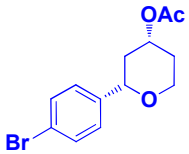
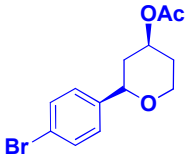
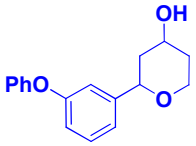
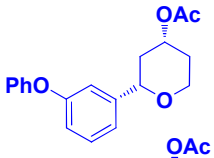
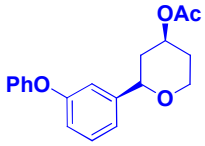
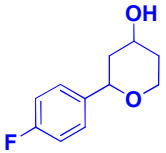
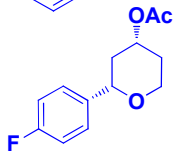
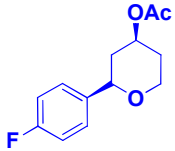
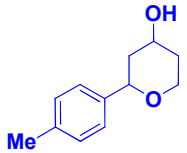
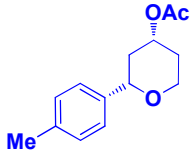
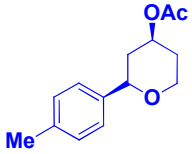
Entry	Prochiral ketone	Product	Time (h)	$[\alpha]_D^{25}$	Yield (%)	ee (%)	Configuration
a			24	-29.0	72	98	*S*
b			72	-23.2	63	91	*S*
c			48	-27.7	71	95	*S*
d			72	+14.1	45	89	*S*
e			72	+15.7	40	87	*S*
f			24	-21.4	35	91	2*S*,4*S*
				+15.7	35	93	2*R*,4*S*
g			24	-21.2	33	87	2*S*,4*S*
				+18.6	32	92	2*R*,4*S*

Enzymatic kinetic resolution of racemic 4-tetrahydropyranols by *Candida rugosa*

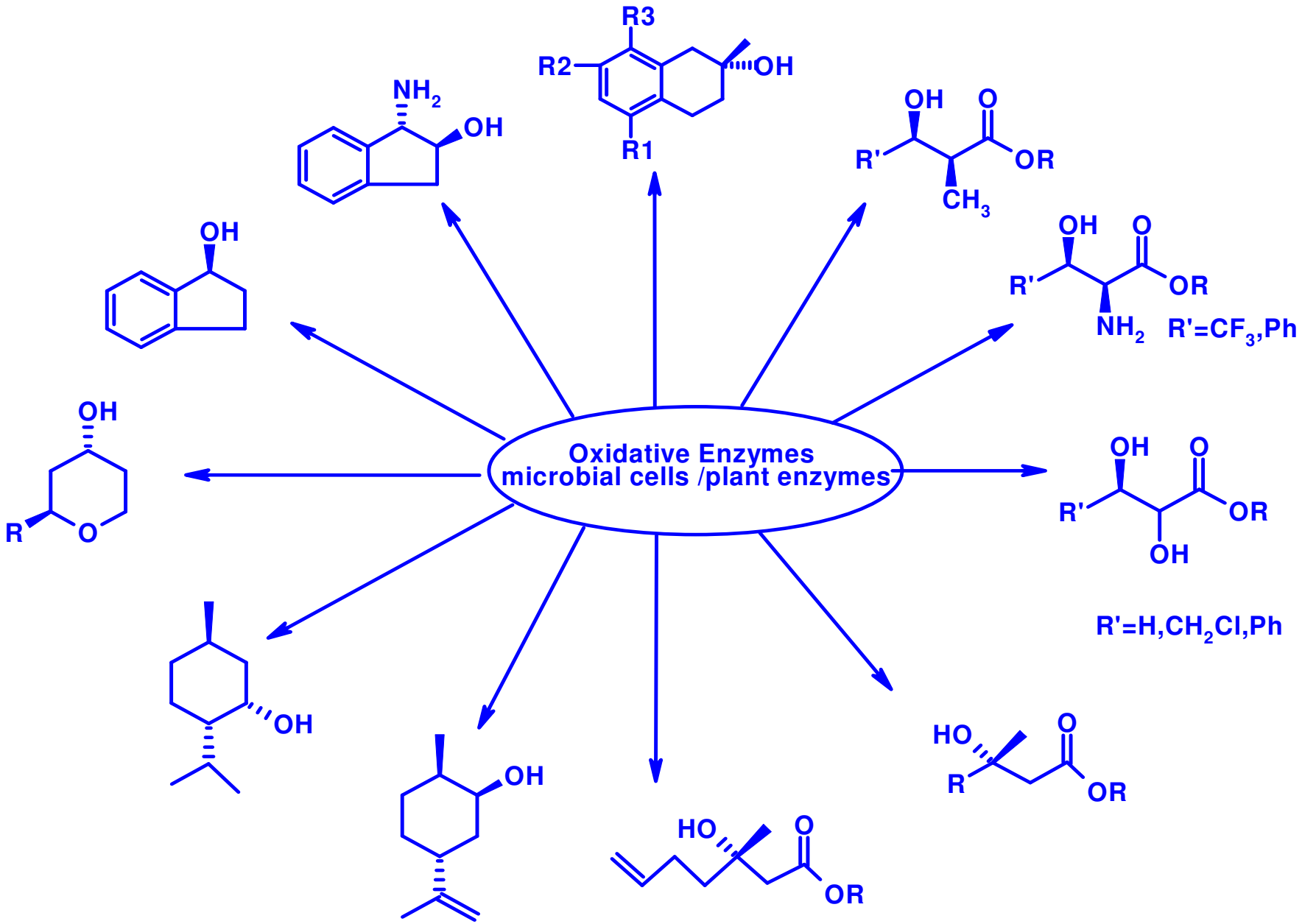


Tetrahedron Lett. 2007, *48*, 4631

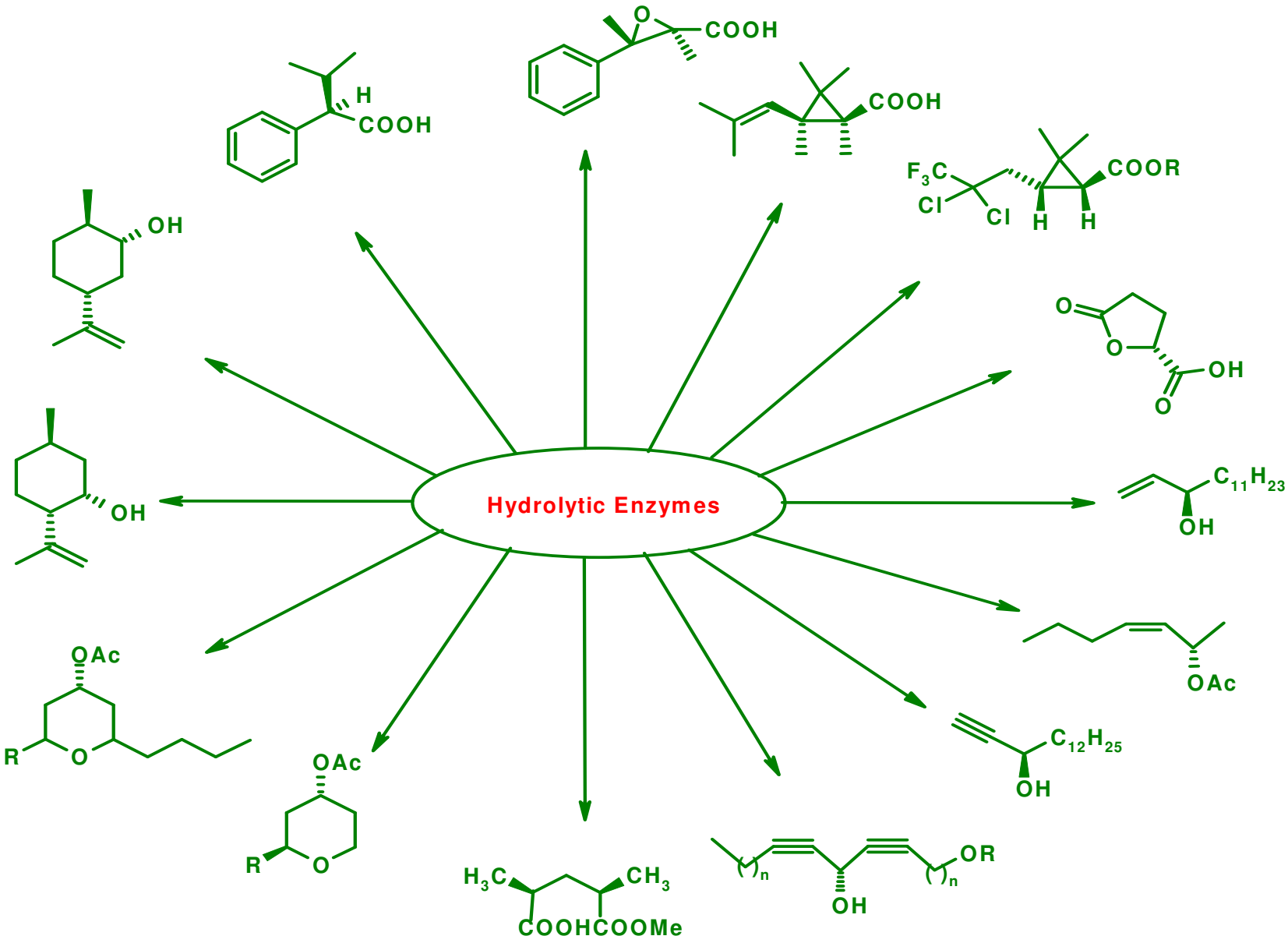
Table 1. Kinetic resolution of tetrahydropyranols using Candida Rugosa

Entry	Substrate	Acetate 2a	$[a]_D^{25}$	ee(%)c	Acetate 3d	$[a]_D^{25}$	Ee(%)	Time (h)	Yield (%)
a			21.2	98		-21.3	95	6	75
b			21.7	90		-18.3	87	10	80
c			29.8	94		-27.9	89	9	85
d			19.6	88		-16.7	83	12	86
e			70.8	98		-62.1	90	8	81
f			8.9	90		-7.5	87	9	82
g			13.9	92		-12.3	88	10	86

BIOCATALYTIC REDUCTION OF PROCHIRAL KETONES/KETOESTERS

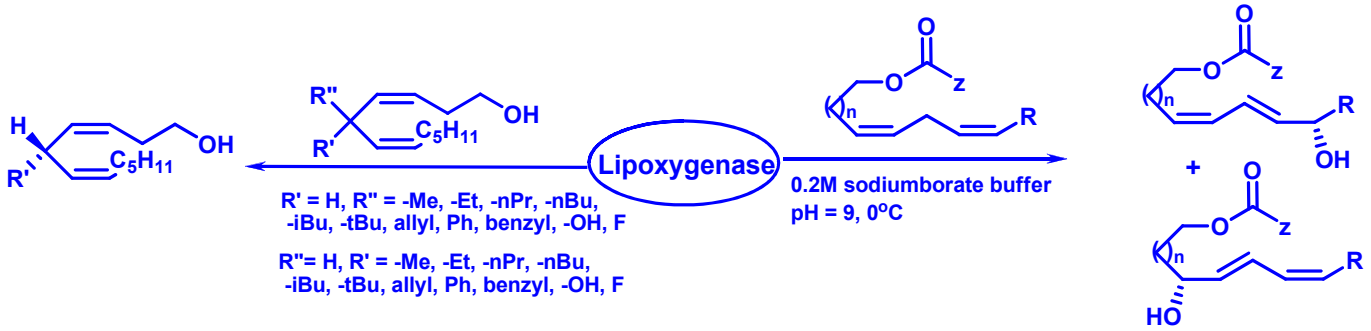


LIPASE-MEDIATED KINETIC RESOLUTION OF ALCOHOLS/ACIDS

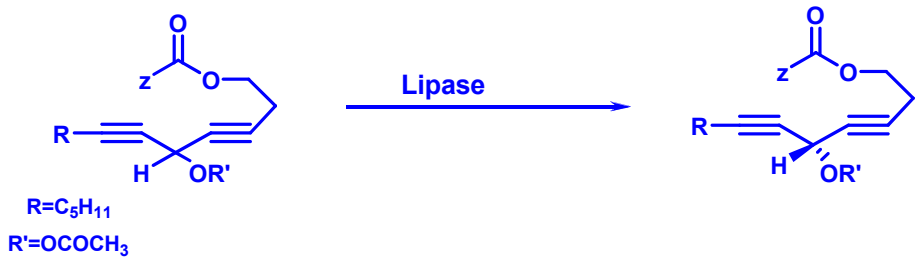


LIPOXYGENASE CATALYZED DIOXYGENATION OF POLYUNSATURATED FATTY ACIDS

- Lipoxygenases are a family of Iron-containing enzymes
- Catalyses the dioxygenation of polyunsaturated fatty acids in lipids containing a cis,cis-1,4- pentadiene structure
- It catalyses the following reaction: fatty acid + O2 = fatty acid hydroperoxide



Enzymatic resolution of Unnatural lipoxygenase substrates



Yadav & Nanda, *J. Mol. Cat. B*: *Enzymatic* 2003, *26*, 3-28

ENZYMATIC DEGUMMING OF RICE BRAN OIL

ENZYMATIC DEGUMMING OF RICE BRAN OIL–
AN OUTSTANDING EXAMPLE FOR GREEN TECHNOLOGY



ENZYMATIC DEGUMMING OF RICE BRAN OIL


M/s. SSD Oil Mills Co. Ltd., Chennai

Biotechnology-based & Environment-friendly Degumming Process to Produce High Quality RBO by Retaining all Nutritional Components (Oryzanol, Tocopherols, Tocotrienols etc.) in the Refined Oil

- Requires Significantly Less Water and No Effluents are Generated
- Covered IPRs [Indian Patent No. 202379 (2006) & US Patent No. 7,494,676 (2009)]
- Technology Transferred to 27 Industries (@50TPD) Covering 9 States
- New Processing Capacity of 2 lakh tons of RBO worth of Rs 900 crores Established
- ~Rs 50 crores Extra Revenue Generated by Existing Units (~2 lakh tonns)
- Process Presently Covers 50% of Country's Production

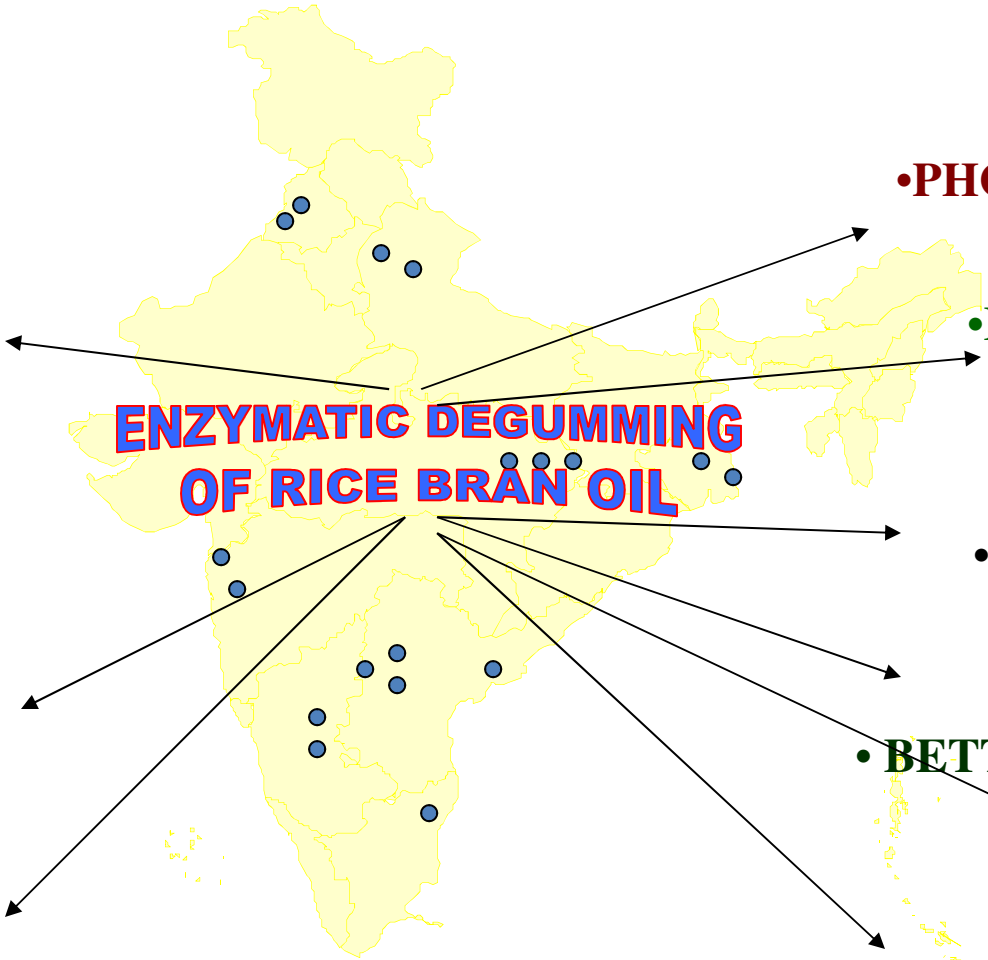
UNIQUENESS OF THE PROCESS

- Extra Oil Recovery @ 1 to 1.5 %
  - Extra Fatty Acid Recovery @ 0.3 to 0.6 %
  - Minimum Water Saving @ 10 % of Crude Oil

Rs.11.25 crores Grant-in-aid from TMOP & M

- ADAPATABLE IN EXISTING REFINERIES
- TMOP&M GRANT OF Rs 75 LAKHS EACH TO 15 OIL REFINERIES
- TECHNOLOGY TRANSFERRED TO 16 INDUSTRIES
- TO COMMISSION 3 MORE PLANTS WITHIN 2 MONTHS
- LICENCE FOR 8 PROJECT ENGINEERING COMPANIES
- 2 LAKH TONNES OIL

27 Clients so far
Covering 9 states



- PHOSPHOROUS LESS THAN 5 PPM
- MINIMUM WATER CONSUMPTION
- NO EFFLUENT
- HIGHER OIL AND FATTY ACID RECOVERY
- BETTER OIL QUALITY
- HIGHER PROFITABILITY
- VALUE ADDITION TO BYPRODUCTS

PEC

IICT — TECHNOLOGY TRANSFER MODE — BENEFICIARY

TMOP/CSIR

Rs.147 lakhs
IICT Consultancy

ENZYMATIC DEGUMMING OF RICE BRAN OIL
(2002 – 2005)

LEVEL	PROJECT ENGINEERING COMPANIES (LICENCEES)	INDUSTRIES
COMMERCIAL SCALE (50 TPD)	1.Muez-Hest Process Technologies Pvt. Ltd. 2.Mecpro heavy Engineering Ltd. 3.Chemical Construction International (P) Ltd. 4.Alfa Laval (India) Ltd. 5.Mectech Process Engineers Pvt. Ltd. 6.Glamptech Agro Process Pvt. Ltd. 7.Lipid Systems Engineers Pvt. Ltd. 8.PEG Consultants and Engineers Pvt. Ltd.	***COMMISSIONED*** 1. A.P. Solvex Pvt. Ltd. (2002) 2. Anil Modi Oil Industries Ltd. (2002) 3. Paras Vanaspati Pvt. Ltd. (2002) 4. Abhay Solvents Pvt. Ltd. (2003) 5. Bhatinda Chemicals Limited (2003) 6. Saraiwala Agro Refineries Ltd. (2003) 7. Ramcharan Oil Industries (2003) 8. Kamal Solvent Extraction Pvt. Ltd. (2003) 9. Dutta Agro Mills Pvt. Ltd. (2004) 10. Jay Shree Solvex Pvt. Ltd. (2004) 11. Sri Murugarajendra Oil Industry Ltd. (2004) 12. A.P. Organics Pvt. Ltd. (2004) 13. Ganpati Solvex Pvt. Ltd. (2004) 14. Paceman Sales Promotion Pvt. Ltd. (2004) 15. S.S.D. Oil Mills Co. Ltd. (2005) 16. Sarda Agro Products Ltd. (2005) 17. Lohiya Vanaspati (P) Ltd. (2005) ***TO BE COMMISSIONED (within 2 months)*** 1. Sona Oil & Chemical Industries Ltd. 2. Bagaria Agro Products Ltd.

Rs. 11.25 Crores Grant-in-aid from TMOP & M

IICT Technology Transfer Fees Rs.147 lakhs

PROCESS ATTRACTED 27 CLIENTS SO FAR

CSIR Technology Award-2005
Technology Award-2009
Green Chemistry Award-2009

ENZYMATIC DEGUMMING OF RICE BRAN OIL



Biotechnology-based & Environment-friendly Degumming Process to Produce High Quality RBO

- **Transferred to 27 Industries**
- **Covered by Patents**







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Acknowledgement : www.googleimages for source of pictures in ppt

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