POLYMER EDUCATION FROM MOLECULAR STRUCTURE TO TECHNOLOGICAL PROPERTIES; REQUIREMENTS IN DEVELOPING COUNTRIES

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EDUCATIONAL BACKGROUND

1. Why do we teach Polymer Science?
2. To whom and by whom is Polymer Science taught?
3. How can instruction in basic Polymer Science be related to capability in Polymer Technology?
4. What aspects are important in developing countries?

EDUCATIONAL BACKGROUND

1. WHY DO WE TEACH POLYMER SCIENCE AND TECHNOLOGY?

Plastics and rubber industries today occupy a position of economic and social importance

THE MIDDLE INCOME TRAP

Reliance on imported technology

Lack of “tacit knowledge”

Little innovative technological research and development

Poor technology management

CAN POLYMER EDUCATION HELP?

THE MIDDLE INCOME TRAP

RESEARCH AND DEVELOPMENT

Successful developed countries:. circa 3% GDP

Middle Income trap countries: 0.2% - 0.5% GDP

Thailand: 0.25%GDP

S. Korea: 4.4%GDP

BREAKING OUT OF THE MIDDLE INCOME TRAP

Requires education in polymer science and technology to be linked to industrial production more necessarily and more intimately than in developed countries.

EDUCATIONAL BACKGROUND

2. BY WHOM IS POLYMER SCIENCE AND TECHNOLOGY TAUGHT?

BY WHOM IS POLYMER SCIENCE AND TECHNOLOGY TAUGHT?

Most lecturers and students have a chemistry background

Most lecturers in developing countries obtained their higher degrees in developed countries

They teach material the way that they were taught

EDUCATIONAL BACKGROUND

3. TO WHOM IS POLYMER SCIENCE AND TECHNOLOGY TAUGHT?

POLYMER EDUCATION IN THAILAND

11 universities offer **degree courses** in polymer science/technology.

10 other university departments in Thailand teach polymer science or engineering but do **not offer degree courses** specific to polymer science and technology.

POLYMER EDUCATION IN THAILAND

Emphasis on synthesis and molecular structure

Under-statement of the relationships between structure and technological properties.

In few cases is the instruction in English language.

Follows American instruction/research model

POLYMER EDUCATION IN THAILAND

“International Programs” are supposed to be given all in English.

Bloom’s Lower Elements of Knowledge and Comprehension: Good

Bloom’s Higher Elements of Analysis and Synthesis: Poor

Polymer Graduate Careers In Thailand

M.Sc 80% to industry, **20%** to the government sector

Ph.D 30% to industry, **50%** to universities **20%** to government research institutes

Polymer Graduate Careers: Special Programs

Rubber Industry: solving its Historical Problems

Mahidol University Centre for Rubber Research and Technology

Prince of Songkla University Natural Rubber Products Technology Transfer Center

Polymer Graduate Careers: Special Programs

Thermoplastic Industries

Outstanding example of coverage

Mahidol University Polymer Science and Technology Program

Compulsory courses in polymer chemistry, polymer physics and polymer technology

4. THE PROBLEM FOR DEVEOPING COUNTRIES

Chemistry, physics and engineering presented in separate unrelated packages.

Discourages holistic inter-subject thinking

STUDENT; IT'S TOO CONFUSING

PHYSICS

CHEMISTRY

ENGINEERING

WHAT SHOULD BE TAUGHT IN SOUTH EAST ASIA

PROGRAM PHILOSOPHY

Students must be moved from learning material in disconnected mental boxes to thinking widely about polymer science and technology in a constructive and integrated way.

PROGRAM PHILOSOPHY

1. What are the technological properties with which we are involved?
2. What are the molecules doing to cause these properties?
3. Why are the molecules doing this?
4. How are the molecules doing this?
5. What do the molecules need in order to do this?
6. How does the molecular structure affect what they are doing?

CHEMISTRY-PHYSICS-TECHNOLOGY:

TO PREPARE STUDENTS TO INTEGRATE WHAT THEY LEARN ABOUT MOLECULAR STRUCTURE AND POLYMER PHYSICS WITH WHAT THEY WILL FACE IN TECHNOLOGY.

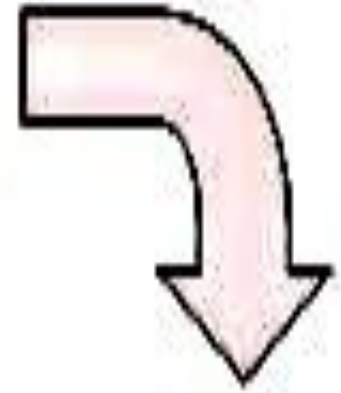
CHEMISTRY-PHYSICS-TECHNOLOGY: A BRIDGE OF UNDERSTANDING

MOLECULAR MOTION

Mechanical Properties, Dielectric Properties, Acoustic Properties

Molecular Motion

Internal Rotation, Libration (Partial Rotation),
Reptation (Translation), Normal Modes



Chemistry

Synthesis, Characterization

Structure Determination

Energy Levels

Technology

Modulus, Compliance

Flow, Creep

Elasticity, Loss, Damping

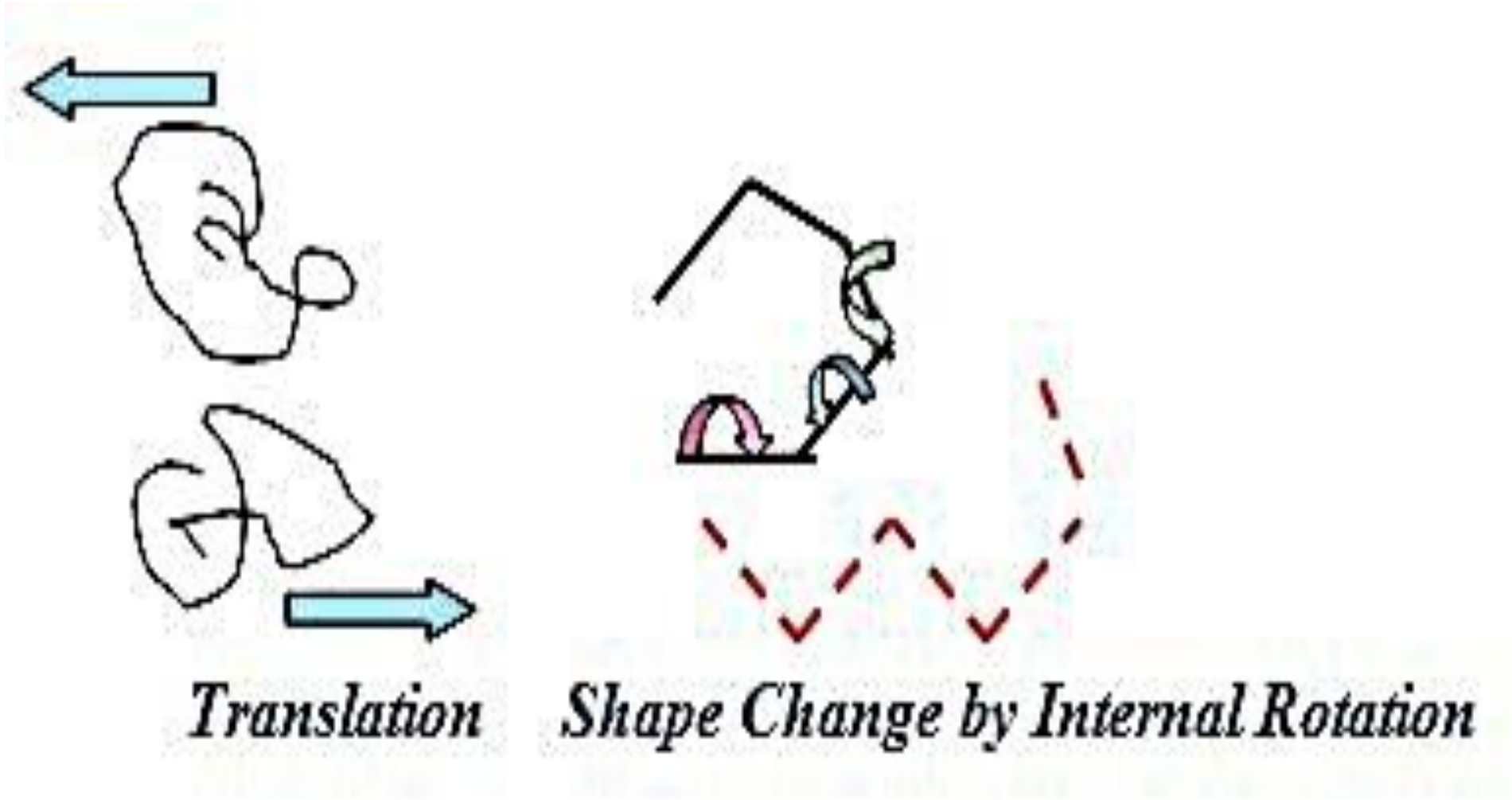
MOLECULAR MOTION

How the molecular structure affects;

1. the shape of the macromolecules

2. shape changes due to stress, temperature, time, available space

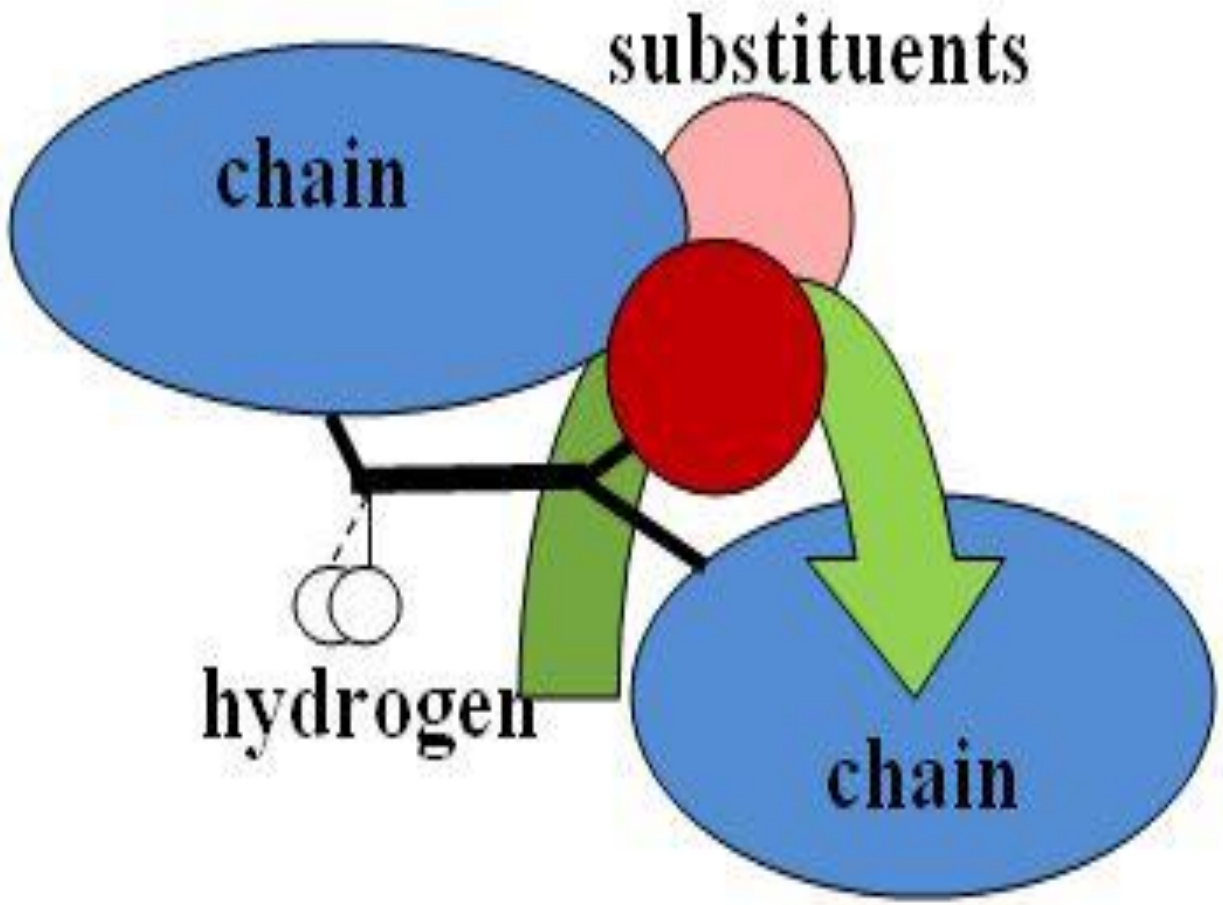
TWO IMPORTANT MOLECULAR MOTIONS



CHEMICAL STRUCTURE AND INTERNAL ROTATION:

MOLECULES NEED ENERGY TO OVERCOME STERIC AND OTHER INTERMOLECULAR FORCES.

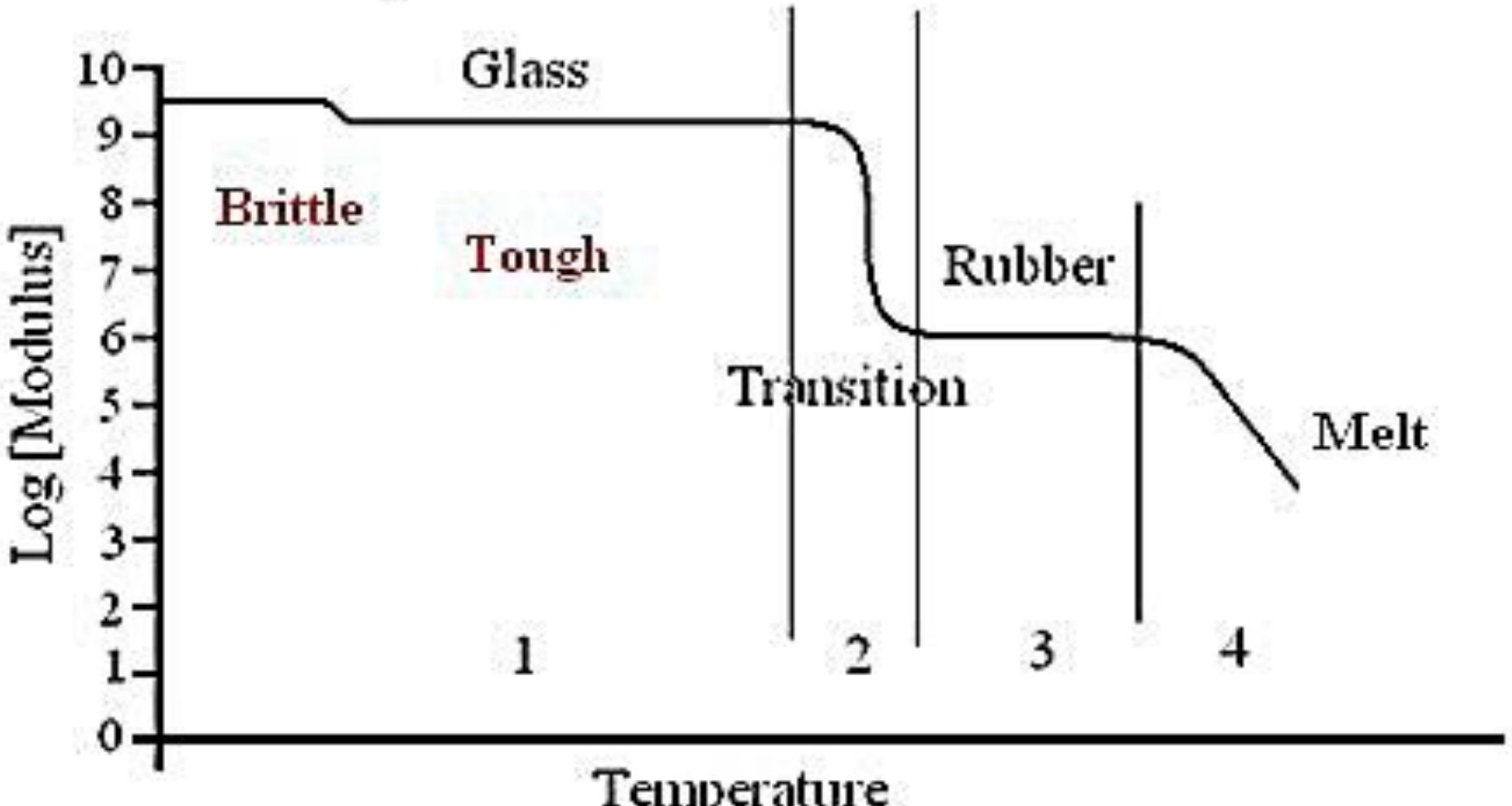
MOLECULES NEED ENERGY TO MOVE.



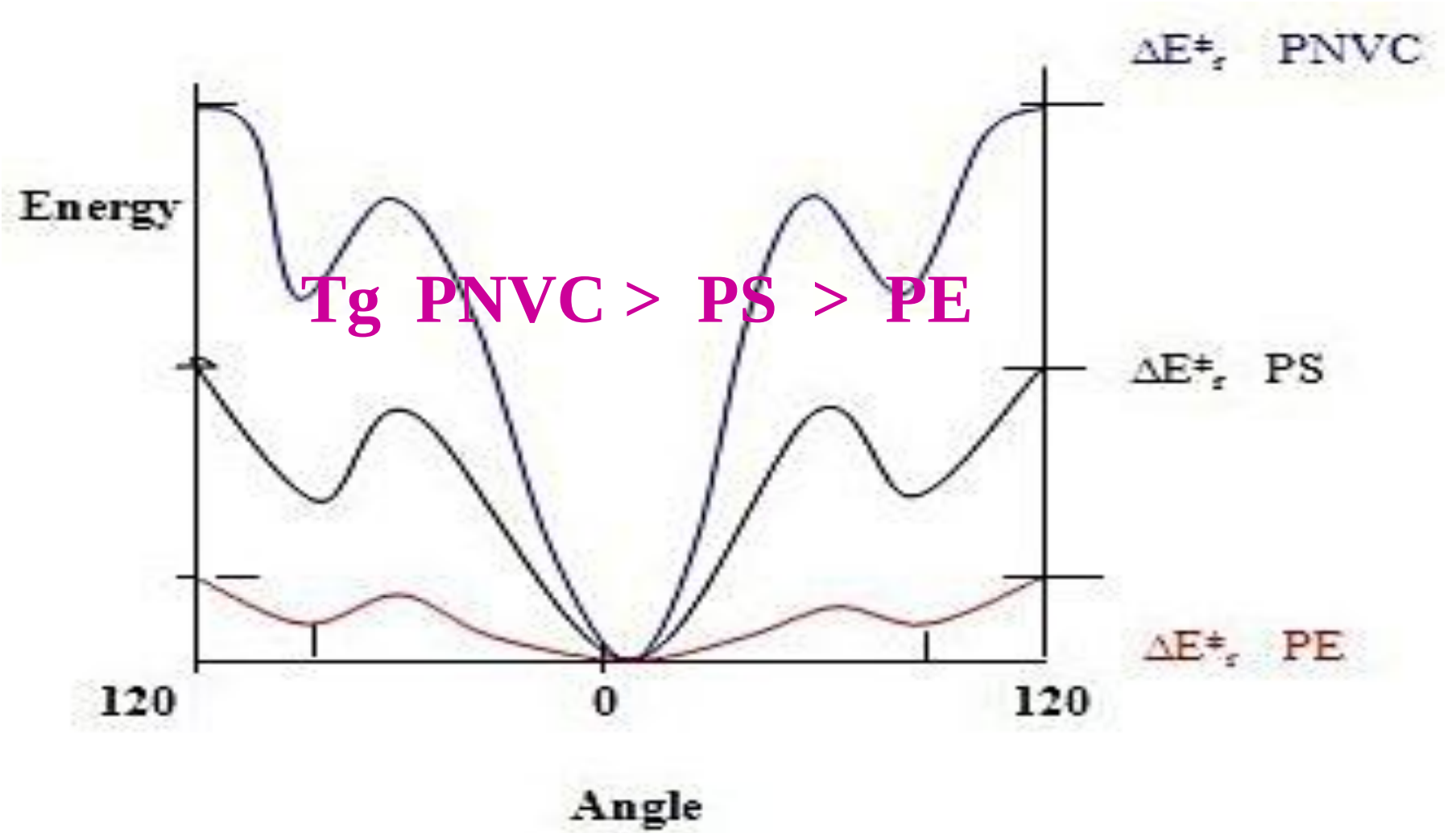
GLASS TO RUBBER TRANSITION

Transition occurs when the thermal energy becomes equal to the molecular internal rotation activation energy.

Modulus Temperature Relationship



IDEALIZED ENERGY-ANGLE PROFILES FOR THREE POLYMERS



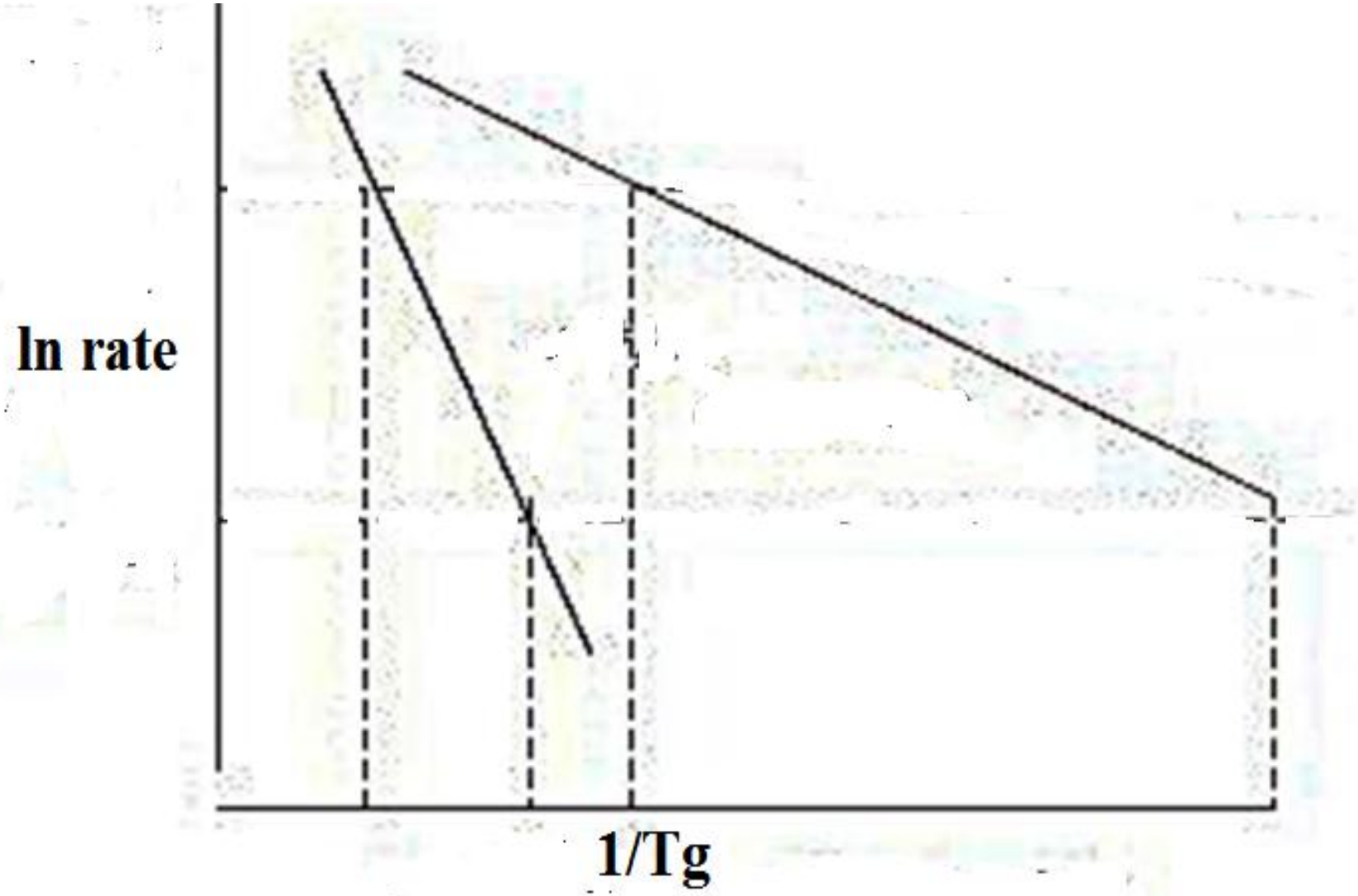
ENERGY LOSS

A LARGE ACTIVATION ENERGY AND A LARGE ENERGY DIFFERENCE BETWEEN ROTATIONAL STATES LEAD TO A LARGE MAXIMUM LOSS.

MOLECULES NEED TIME TO MOVE

THE MACROSCOPIC GLASS TRANSITION TEMPERATURE IS NOT A CONSTANT FOR A PARTICULAR POLYMER, BUT IS A FUNCTION OF BOTH THE CHEMICAL STRUCTURE AND THE TIME/FREQUENCY OF OBSERVATION.

Arrhenius Diagram Ln Rate against 1/Tg



RATE-Tg RELATIONSHIP

FOR A GIVEN CHANGE IN RATE, THE CHANGE IN Tg IS GREATER FOR LOW ACTIVATION ENERGY THAN FOR HIGH ACTIVATION ENERGY

CHALLENGER DISASTER

MOLECULES NEED FREE VOLUME TO MOVE INTO

Why there is a minimum transition temperature no matter how slow the observation may be

COHEN AND TURNBULL

APPLICATION OF MOLECULAR STRUCTURE TO GLASS PHYSICAL PROPERTIES

WHY GLASSES ARE TOUGH BETWEEN THE MAIN α TRANSITION AND THE SECONDARY β TRANSITION

LIBRATION TO FULL ROTATION

APPLICATION OF MOLECULAR STRUCTURE TO RUBBER PHYSICAL PROPERTIES

WHY RUBBERS ARE ELASTIC WITH A RESTORING FORCE INVERSELY PROPORTIONAL TO THE MOLECULAR WEIGHT BETWEEN CROSSLINKS

BOLTZMANN MOONEY-RIVLIN ENTROPIC FORCE

APPLICATION OF MOLECULAR STRUCTURE TO RUBBER PHYSICAL PROPERTIES

WHY RUBBERS HAVE ENERGY ABSORPTION (LOSS) PROPERTIES THAT DEPEND ON BOTH THE ACTIVATION ENERGY FOR SEGMENTAL ROTATION AND THE ENERGY DIFFERENCE BETWEEN ROTATIONAL ENERGY STATES.

APPLICATION OF MOLECULAR STRUCTURE TO MELT PHYSICAL PROPERTIES

WHY MELTS HAVE A VISCOSITY PROPORTIONAL TO THE 3.5 POWER OF MOLECULAR WEIGHT

REPTATION (DE GENNE, EDWARDS)

APPLICATION OF MOLECULAR STRUCTURE TO ELECTRICAL PHYSICAL PROPERTIES

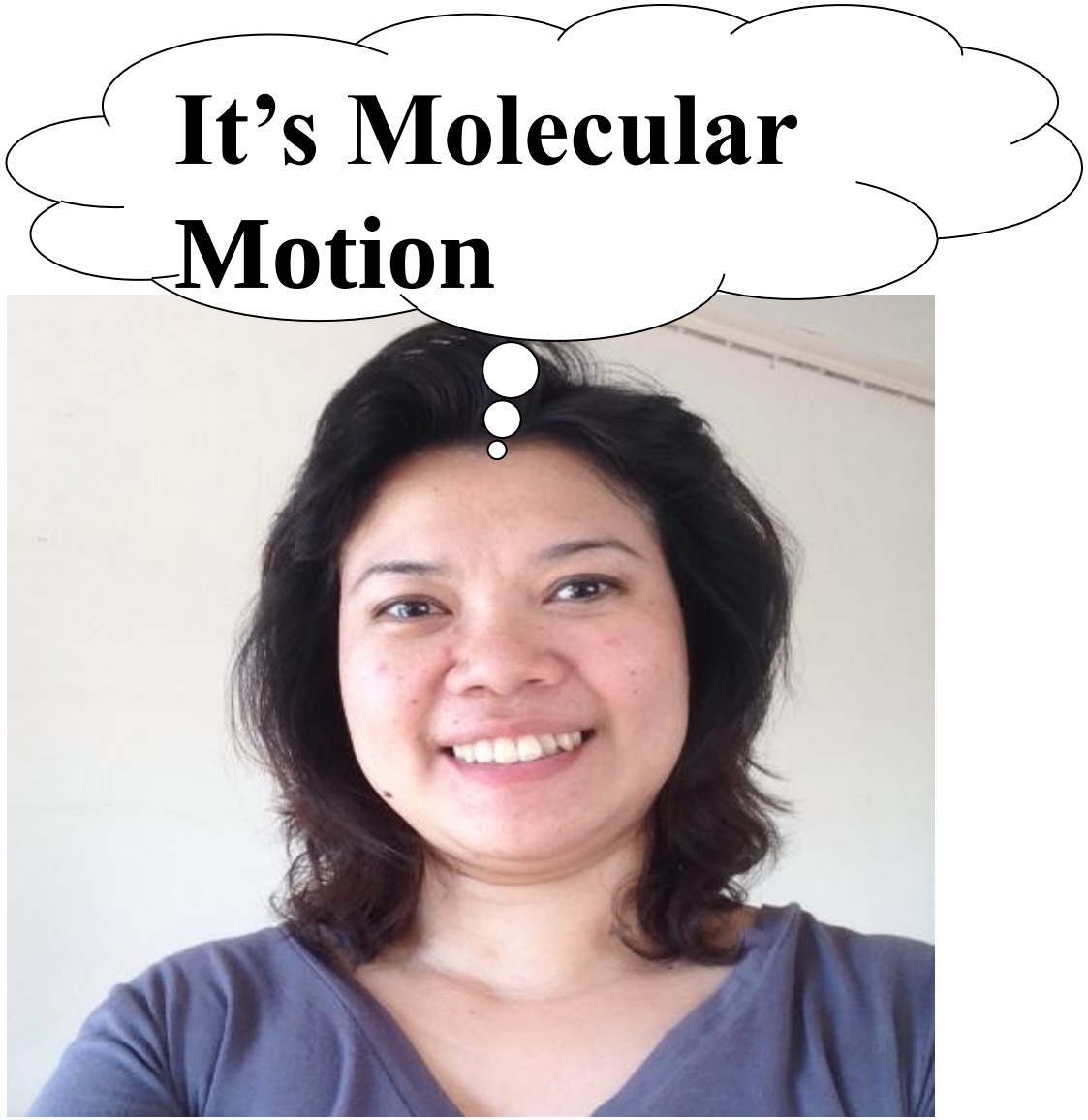
WHY DIELECTRIC PROPERTIES INVOLVING DIPOLE MOVEMENT HAVE MUCH IN COMMON WITH MECHANICAL PROPERTIES.

APPLICATION OF MOLECULAR STRUCTURE TO ACOUSTIC PHYSICAL PROPERTIES

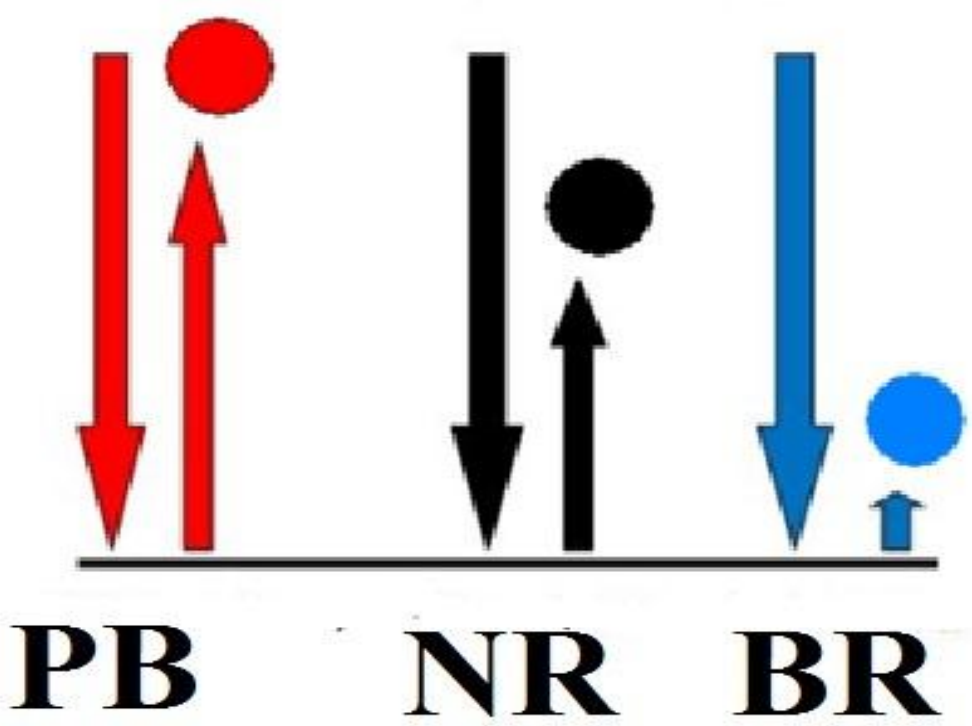
WHY ACOUSTIC PROPERTIES ALLOW US TO EVALUATE ENERGY ABSORPTION CHARACTERISTICS OF LOSS

SCHOTTKY EQUATION

Graduate; Now I understand



THE PROBLEM: AN EXAMPLE



Bouncing Balls

Universities in Thailand which offer degree courses in polymer science/technology (B.Sc,M.Sc,Ph.D)

1. The Petroleum and Petrochemical College, Chulalongkorn University
2. The Petrochemical and Polymer Science Program, Faculty of Science, Chulalongkorn University

3. Department of Materials Science, Faculty of Science, Chulalongkorn University
4. Department of Polymer Engineering, Suranaree University of Technology
5. Department of Chemistry, Faculty of Science, Mahidol University
6. Department of Rubber Technology and Polymer Science, Faculty of Science and Technology, Prince of Songkla University, Pattani

Universities in Thailand which offer degree courses in polymer science/technology (B.Sc,M.Sc,Ph.D)

7. Department of Materials Science and Technology, Faculty of Science, Prince of Songkla University, Hatyai
8. Faculty of Science and Industrial Technology, Prince of Songkla University, Surat Thani
9. Department of Materials Science, Faculty of Engineering and Industrial Technology, Silpakorn University
10. Department of Chemistry, Faculty of Science, King Mongkut's Institute of Technology, Ladkrabang
11. Department of Chemistry, Faculty of Science, Khon Kaen University

Universities in Thailand which teach polymers or are engaged in polymer research but do not offer degree courses in polymer science and technology directly

1. Department of Textile Science and Technology, Faculty of Science and Technology, Thammasat University
2. Division of Meterials Technology, School of Energy, Environment and Materials, King Mongkut's University of Technology, Thonburi
3. Department of Materials Engineering, Faculty of Engineering, Kasetsart University
4. Department of Industrial Chemistry, Faculty of Applied Science, King Mongkut's University of Technology North Bangkok
5. Department of Materials and Matallurgy, Faculty of Engineering, Rajamangala University of Technology Thanyaburi

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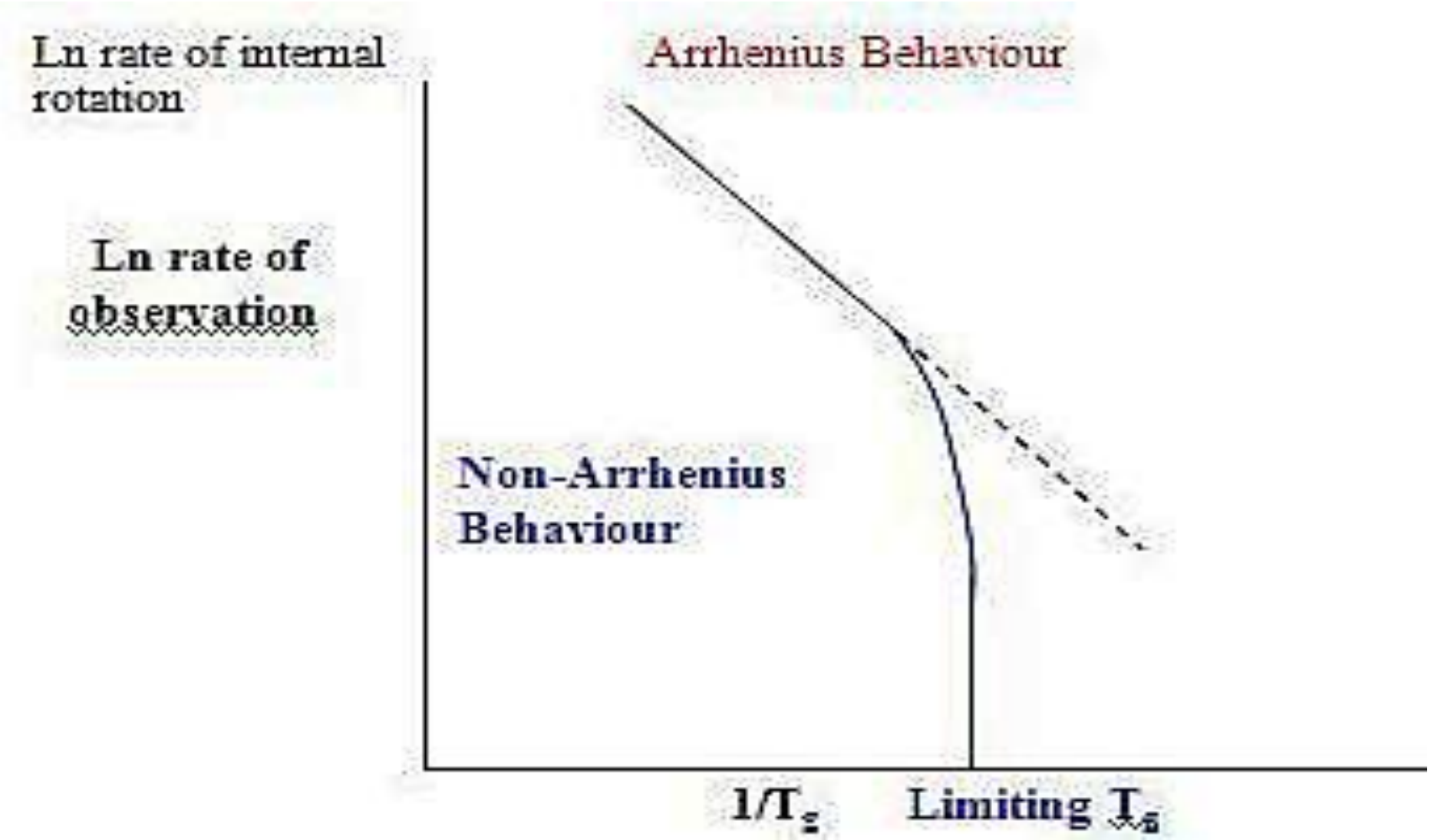
Universities in Thailand which teach polymers or are engaged in polymer research but do not offer degree courses in polymer science and technology directly

6. Department of Chemical Engineering , Faculty of Engineering, Chulalongkorn University
7. Department of Textile Science, Faculty of Agro-Industry, Kasetsart University
8. Department of Industrial Chemistry Faculty of Science, Chiang Mai University
9. Department of Chemistry, Faculty of Science, King Mongkut's University of Technology Thonburi
10. Materials Division, School of Science, Mae Fah Luang University

MINIMUM LIMITING Tg



EFFECT OF OBSERVATION RATE