Mass Transfer

Mass Transfer Theory

- Mass transfer means the movement of substances from one place to another because of concentration differences.
- In fermentation, mass transfer mainly refers to movement of nutrients, gases, and products between different phases.

Definition of Mass Transfer

- Mass transfer is the transport of molecules from a region of higher concentration to a region of lower concentration.
- It is very important in bioreactors because microorganisms need nutrients and gases for growth.
- It affects microbial activity and product formation.

Importance of Mass Transfer in Fermentation

- Microorganisms need oxygen and nutrients.
- Products and waste materials must move away from cells.
- Efficient mass transfer increases productivity.
- Poor mass transfer can limit fermentation performance.

First Hope

Types of Mass Transfer

1. **Molecular Diffusion**
   - Molecular diffusion occurs when molecules move due to concentration differences.
   - It happens naturally without mechanical movement.
   - It is common in transfer of dissolved substances.
2. **Convective Mass Transfer**
   - Convective transfer occurs due to bulk movement of liquid or gas.
   - Agitation and aeration improve this type of transfer.

Phases Involved in Mass Transfer

Mass transfer in fermentation often occurs between:

1. **Gas to Liquid Transfer**
   - Oxygen moves from air bubbles into liquid broth.
2. **Liquid to Cell Transfer**
   - Nutrients and oxygen move from liquid to microorganisms.

Copyright by Engacy Learning Private Limited. All rights reserved. Reproduction or distribution without written consent is strictly prohibited.

3. Cell to Liquid Transfer

- Products and wastes move from cells into liquid.

4. Driving Force for Mass Transfer

- The driving force is usually concentration difference.
- Greater concentration difference increases transfer rate.

Fick's Law of Diffusion

- Mass transfer by diffusion follows Fick's Law.
- It states that diffusion rate is proportional to concentration gradient.
- Higher concentration difference causes faster diffusion.

Mass Transfer Coefficient

- It shows how efficiently material is transferred.
- It is represented by symbols such as kL or kLa.
- It is important in oxygen transfer studies.

Factors Affecting Mass Transfer

- Agitation speed.
- Aeration rate.
- Bubble size.
- Temperature.
- Medium viscosity.
- Reactor design.

Role of Mass Transfer in Bioreactors

- **Mass transfer helps in:**
  - Oxygen supply.
  - Nutrient transport.
  - Removal of carbon dioxide.
  - Product recovery.

Diffusional Resistance to Oxygen Requirements of Microorganisms

- Microorganisms require oxygen for respiration in aerobic fermentation.
- Sometimes oxygen movement to cells is slowed by barriers called diffusional resistances.

Copyright by Engacy Learning Private Limited. All rights reserved. Reproduction or distribution without written consent is strictly prohibited.

Definition of Diffusional Resistance

- Diffusional resistance means opposition to movement of oxygen from air to cells.
- It reduces oxygen transfer efficiency.
- It can limit microbial growth.

Oxygen Requirement of Microorganisms

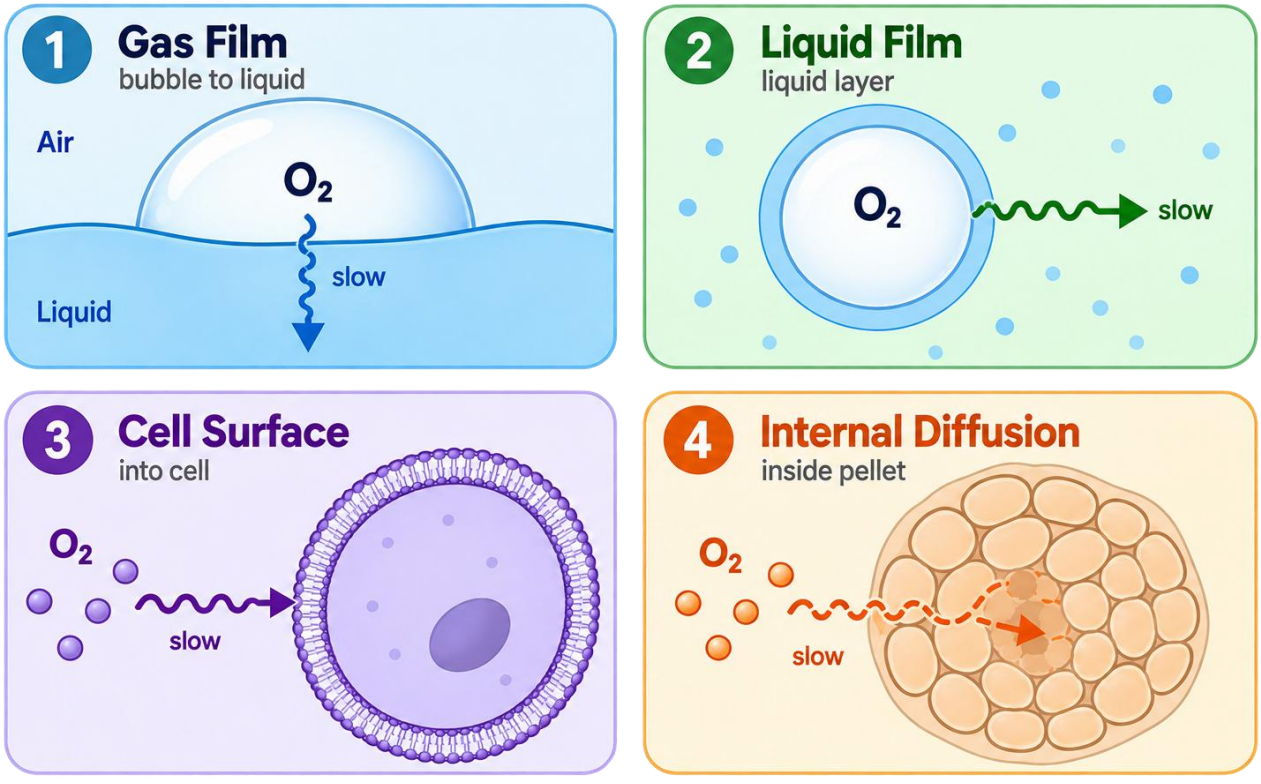
- **Aerobic microorganisms need oxygen for:**
  - Energy production.
  - Cell growth.
  - Product formation.
  - Metabolic reactions.

Path of Oxygen Transfer

- **Oxygen moves through several steps:**
  - From air bubble to liquid surface.
  - Through liquid film around bubble.
  - Through fermentation broth.
  - Through liquid film around cells.
  - Into microbial cells.
- Resistance may occur at any step.

First Hope

Types of Diffusional Resistance



Copyright by Engacy Learning Private Limited. All rights reserved. Reproduction or distribution without written consent is strictly prohibited.

1. Gas Film Resistance

- Resistance may occur at the gas-liquid interface.
- It slows oxygen transfer from bubble to liquid.

2. Liquid Film Resistance

- Thin liquid layer around bubbles may resist oxygen movement.
- This is often a major resistance.

3. Cell Surface Resistance

- Oxygen may face resistance while entering cells.

4. Internal Diffusion Resistance

- Oxygen movement inside cell aggregates may be slow.
- This is common in pellets or biofilms.

Oxygen Transfer Limitation

- If oxygen transfer is slower than oxygen demand, limitation occurs.
- Microbial growth may decrease.
- Product formation may be affected.

Factors Increasing Diffusional Resistance

1. High Viscosity

- Thick broth slows oxygen movement.

2. Large Cell Aggregates

- Oxygen may not reach inner cells easily.

3. Poor Agitation

- Reduces mixing and oxygen distribution.

4. Low Aeration

- Decreases oxygen availability.

Reducing Diffusional Resistance

- **Resistance can be reduced by:**
  - Increasing agitation.
  - Increasing aeration.
  - Using better impeller designs.
  - Reducing broth viscosity.

Copyright by Engacy Learning Private Limited. All rights reserved. Reproduction or distribution without written consent is strictly prohibited.

- Improving reactor design.

Importance in Fermentation

- Understanding oxygen resistance helps improve productivity.
- It is very important in aerobic industrial fermentation.

Measurement of Mass Transfer Coefficient and Factors Affecting Them

- Mass transfer coefficient indicates how efficiently substances, especially oxygen, are transferred to a bioreactor.

Definition of Mass Transfer Coefficient

- It measures the rate of transfer of a substance between phases.
- In fermentation, oxygen transfer coefficient is very important.
- It is often represented as kLa.

Meaning of kLa

kLa consists of:

kL

- It is liquid film mass transfer coefficient.
- It indicates oxygen transfer through liquid film.

a

- It is interfacial area between gas and liquid.
- More bubble surface means larger value of a.

kLa

- It combines both factors.
- It represents overall oxygen transfer ability.

Importance of kLa

- It shows efficiency of oxygen supply.
- It helps in reactor design.
- It is important in scale-up.
- Higher kLa usually means better oxygen transfer.

Measurement of Mass Transfer Coefficient

1. Sulfite Oxidation Method

First Hope

Copyright by Engacy Learning Private Limited. All rights reserved. Reproduction or distribution without written consent is strictly prohibited.

First Hope

FREE PREVIEW

Click here to visit our website

PHARMACY PREMIUM NOTES

Complete subject and semesters are available on FirstHope app only.

Scan or click here

Click here to get the app >

Available on Google Play

JOIN THE FIRSTHOPE COMMUNITY

Join our Telegram channel

Click here to join Telegram >

Scan or click here

@FirstHopeNotes

Instagram

@firsthope.official

Click here to follow >

YouTube channel

FirstHope-Pharmacy / Live streams

Click here to watch >

WhatsApp channel

Follow FirstHope on WhatsApp

Click here to join >

FirstHope website

firsthope.co.in

Click here to visit >

B.Pharm / D.Pharm / M.Pharm / Pharm.D

Preview notes. Complete subjects and semesters in the FirstHope app.