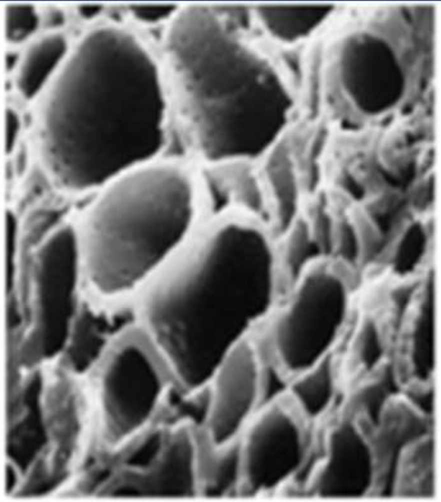
# *Super-capacitor*



Structure microscopique d'une électrode au charbon actif
(porosité de type cylindrique)

# *Super-capacitor*

Supercapacitors are electrochemical devices with following features:

- High energy density.
- High power density.
- High capacitance.
- Longer life

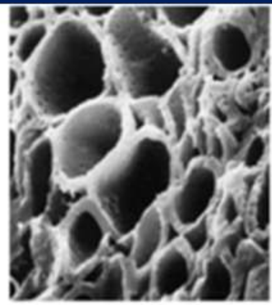
# *Principle Construction*

*It consists of following components:*

- *Current collector:  Metal contacts are used as current collectors .*

$$E = \frac{1}{2} C \times V^2$$

$$C = \varepsilon_0 \varepsilon_r (S/d)$$



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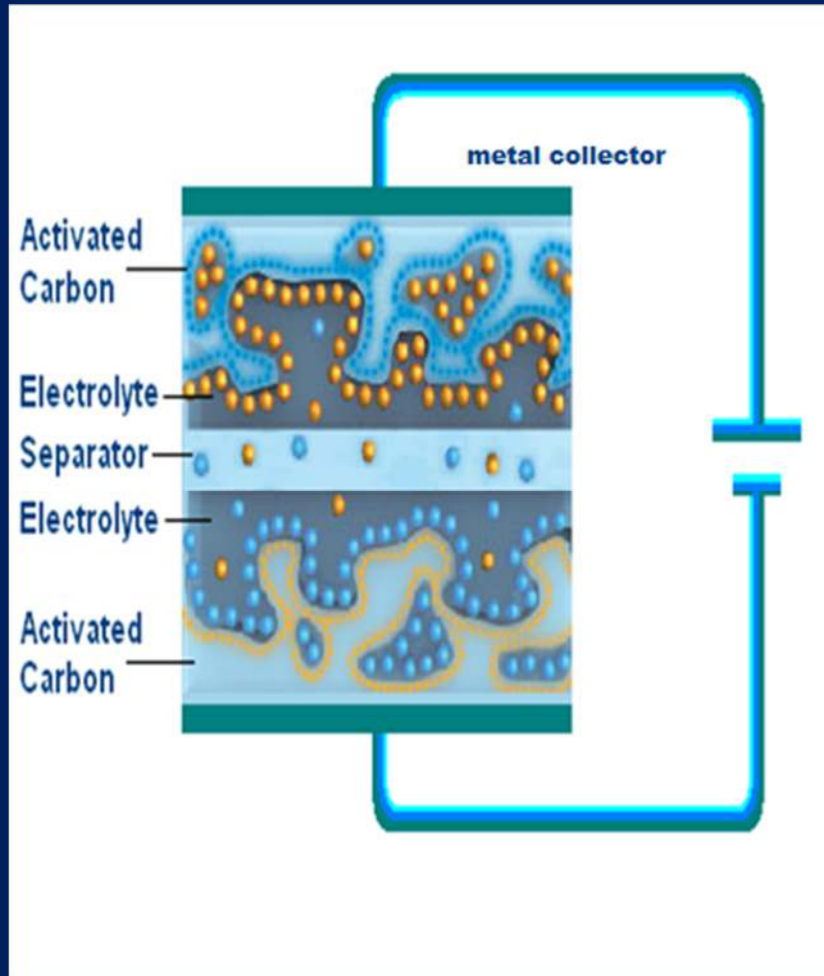



**The effective surface area can reach <u>3000$m_2$ per gram</u> of activated carbon !!!**

**Polarized electrode**: Highly activated carbon is used as electrode because of following reasons:

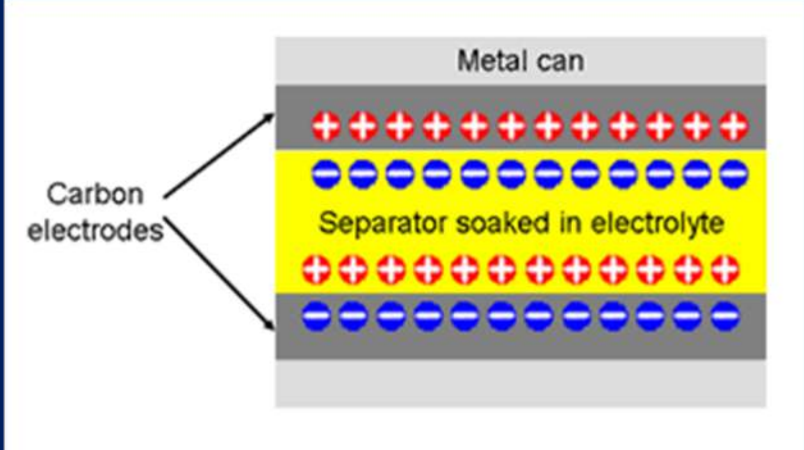
- It is highly porous
- It has extraordinarily high specific surface area
- It has good conductivity
- High temperature and chemical stability
- Corrosion resistant

# *Electrolyte*

*It contains dissolved and solvated ions that migrate to and from the electrodes during charge and discharge respectively.*

Electrolytes are of two types:

- Water soluble
- Water insoluble

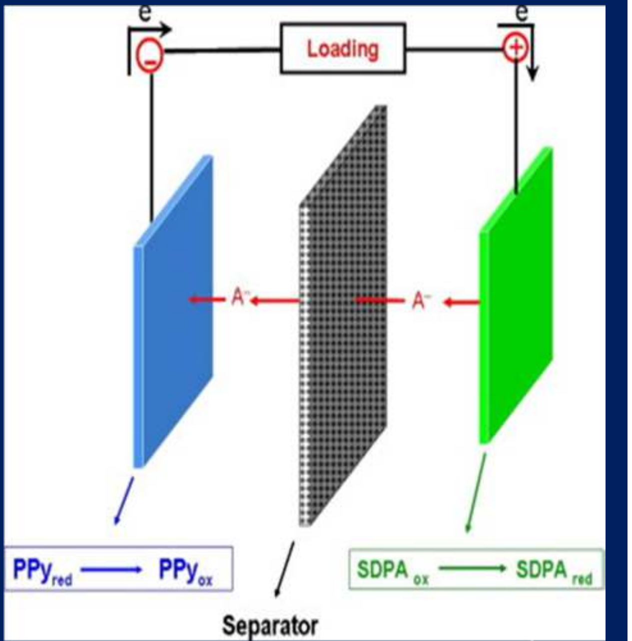


Double Layer Capacitor

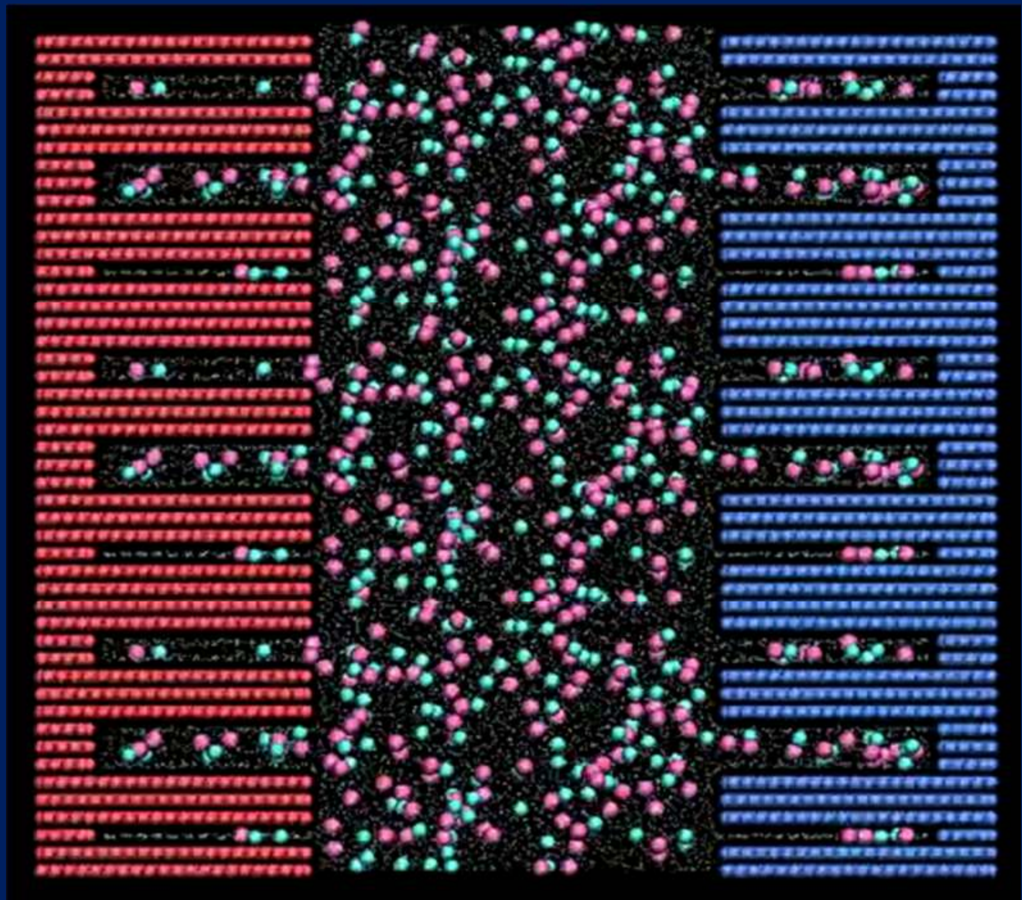
# Separator

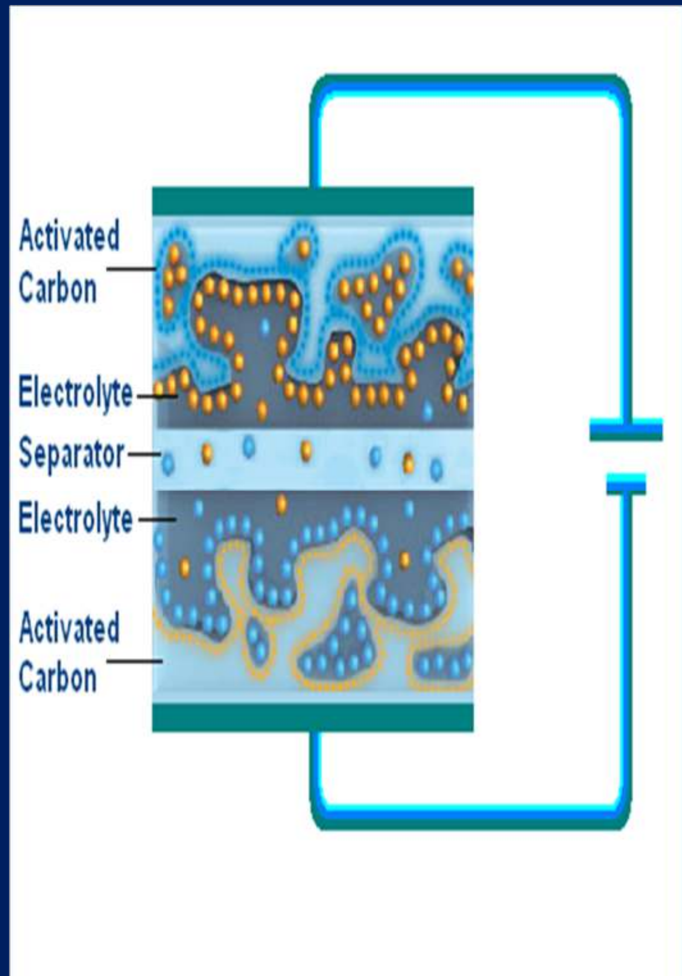
***It acts as mechanical separation between two electrodes.***

- *It must provide electronic insulation between the electrode of opposite polarization*
- *It must support ionic conduction from one electrode to another.*

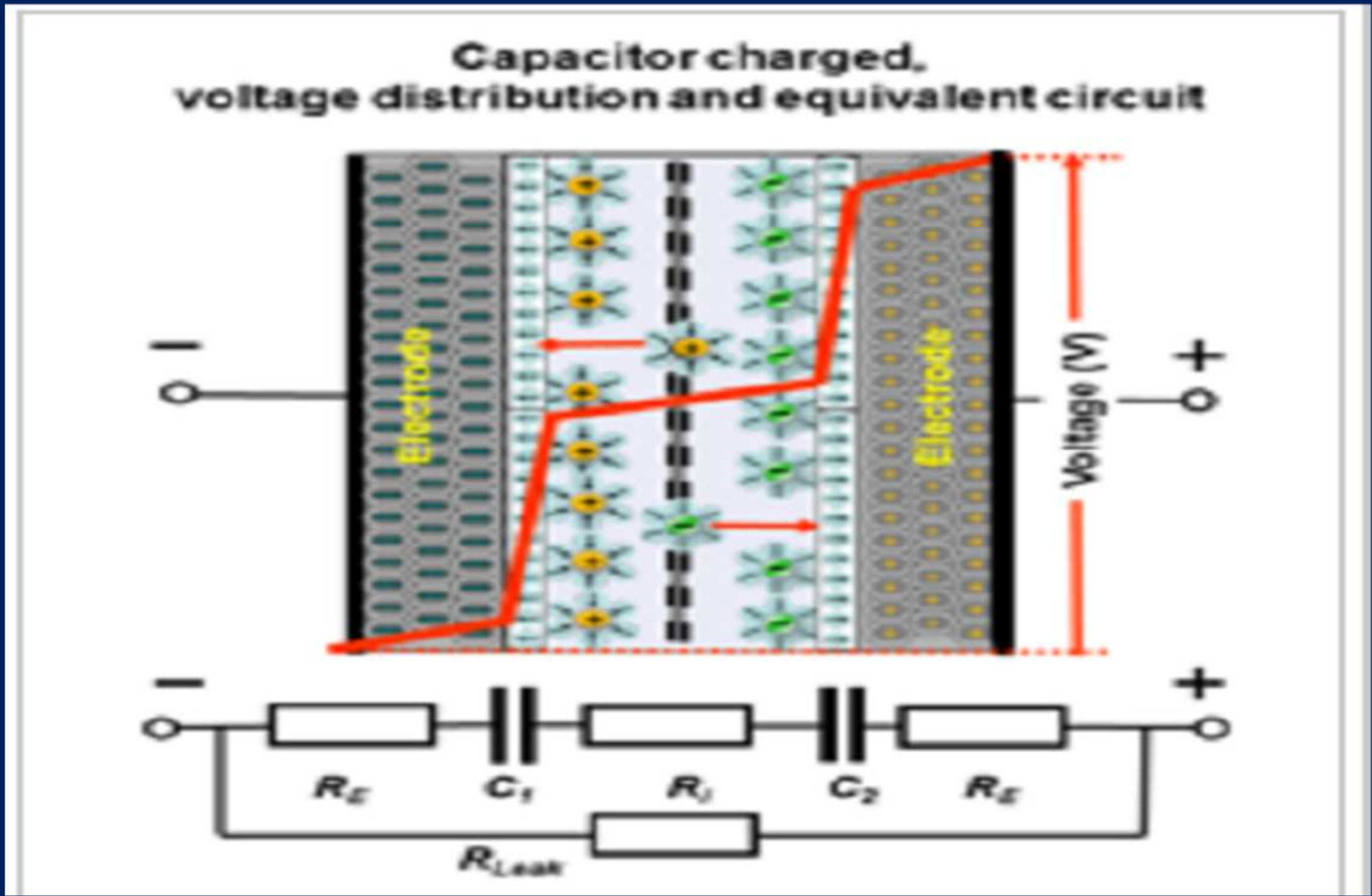


# WORKING




Activated Carbon
Electrolyte
Separator
Electrolyte
Activated Carbon

# Equivalent circuit



# *Manufacturers & Specifications*

| Sl.No. | Manufacturer | Specifications of Supercapacitors |
|---|---|---|
| 1 | Power Star China Make (single Unit) | 50 F/2.7V,<br>300F/2.7V,<br>600F/2.7 V, ESR less than 1mΩ. |
| 2 | Panasonic Make (Single Unit) | 0.022-70F, 2.1-5.5V,<br>ESR 200 mΩ-350 Ω |
| 3 | Maxwell Make (Module) | 63F/125V, 150A ESR 18 mΩ<br>94F/75 V, 50 A, ESR 15 mΩ |
| 4 | Vinatech Make | 10-600F/2.3V, ESR 400 -20 mΩ,<br>3-350F/2.7, ESR 90-8 mΩ |
| 5 | Nesscap Make (module) | 15V/33F, ESR 27 mΩ<br>340V/ 51F, ESR 19 mΩ |

## Super-capacitors

Braking energy recovery

a power peak in the start-up phase and increased performance of hybrid systems

### Advantages

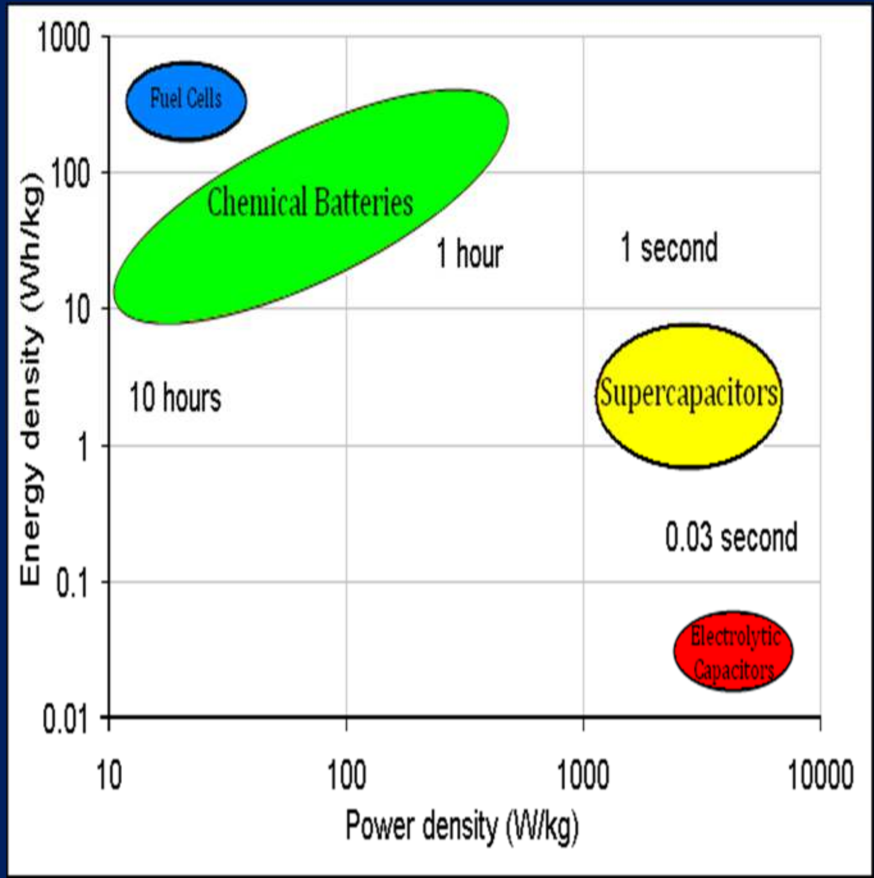
- High energy storage
- Low ESR and hence high power density
- Appreciable operating temp.(-40°C to 70°C)
- Eco-friendly

### Disadvantages

- Low voltage per cell
- It can't be used in AC & high frequency circuits

# Comparison

| Function | Electronic capacitor | Super capacitor | Battery |
|---|---|---|---|
| Charge time | µs – ms | ms-min | Hours |
| Discharge time | µs – ms | ms-days | 1-900 min |
| Energy density | <.01 Wh/L | 0.5-5 Wh/L | 50-300 Wh/L |
| Power density | >$10^4$ W/L | $10^3$-$3x10^3$ | <500 W/L |
| Cycle life | $10^6$-$10^8$ | $10^6$-$10^8$ | 200-1,000 |

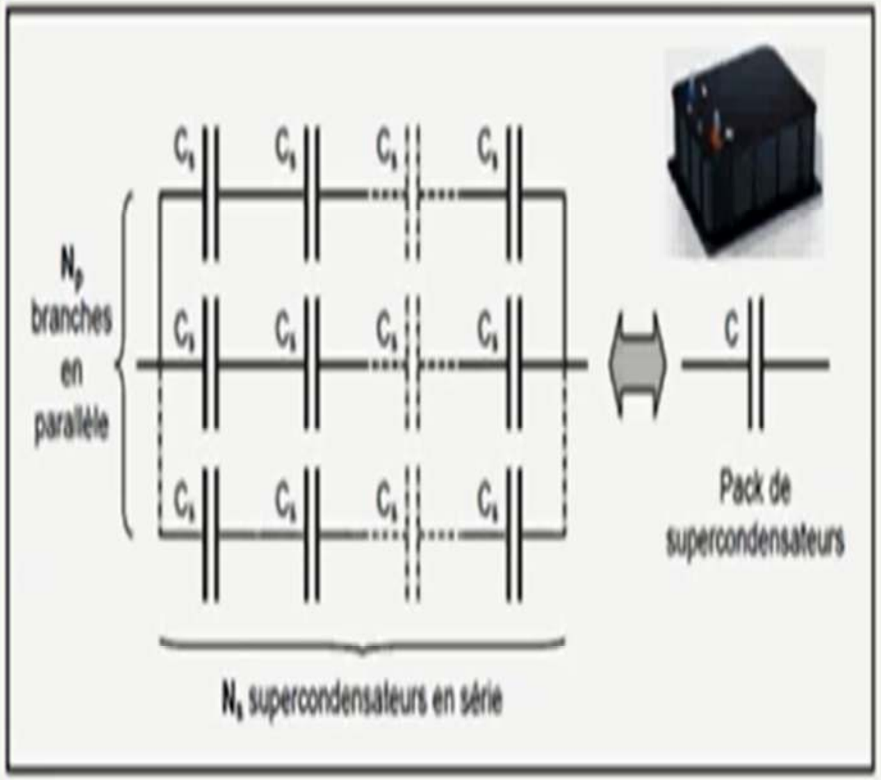


# *Applications*

- Used in Diesel engine start up in submarines & tanks.
- Used to recover braking energy in HEV & modern trains and deliver the same during accelerating periods.
- Can be used in f &V control in power systems
- Used as backup energy source for GPS guided missiles

Light rail vehicle in Hong Kong

The Paris T3 line runs without overhead wires in some sections

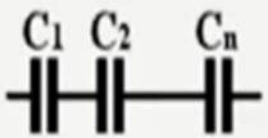


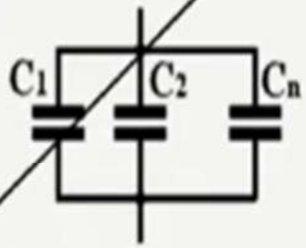

***Exemple***


CdcF impose une tension 400V → 400V / 2.8V =
**143 condensateurs en série**
→La capacité (farad) d'une branche :
$C_{\text{équivalent série}}$ = 3000F / 143 = 21 F

Cdcf impose $E_{totale}$ = 5kWh = 5000*3600 J
= 18 000 000J
18 000 000= ½ .$C_{total}$ . $U^2$
→ $C_{total}$ = 18 000 000 x 2 / $U^2$
$C_{total}$ = 225 F
$C_{total}$ = n x $C_{\text{équivalent série}}$ → **n = 225/21= 11 → 11**

Association en Série et en //




$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots + \frac{1}{C_n}$$

$$C = C_1 + C_2 + \ldots + C_n$$