PROBLEM#15

BLOWING BUBBLES

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PROBLEM STATEMENT

- When blowing on a soap film in the ring, a bubble may be formed. The liquid film may pop or continue to exist. Investigate how the number of bubbles produced from a single soap film and the characteristics of the bubbles depend on the relevant parameters.

PRELIMINARY OBSERVATIONS

ANALYSIS

THEORY

EXPERIMENTAL SETUP

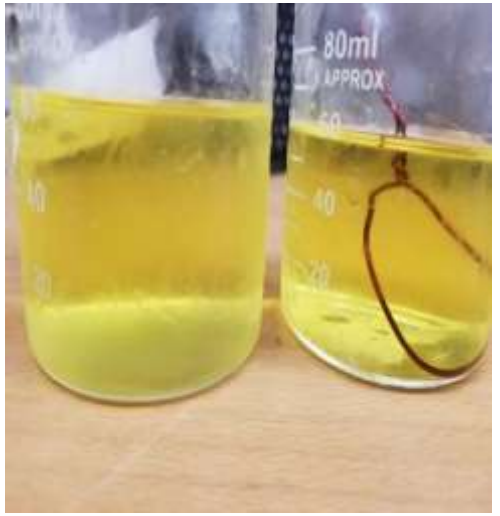
CONCLUSION

PRELIMINARY OBSERVATIONS

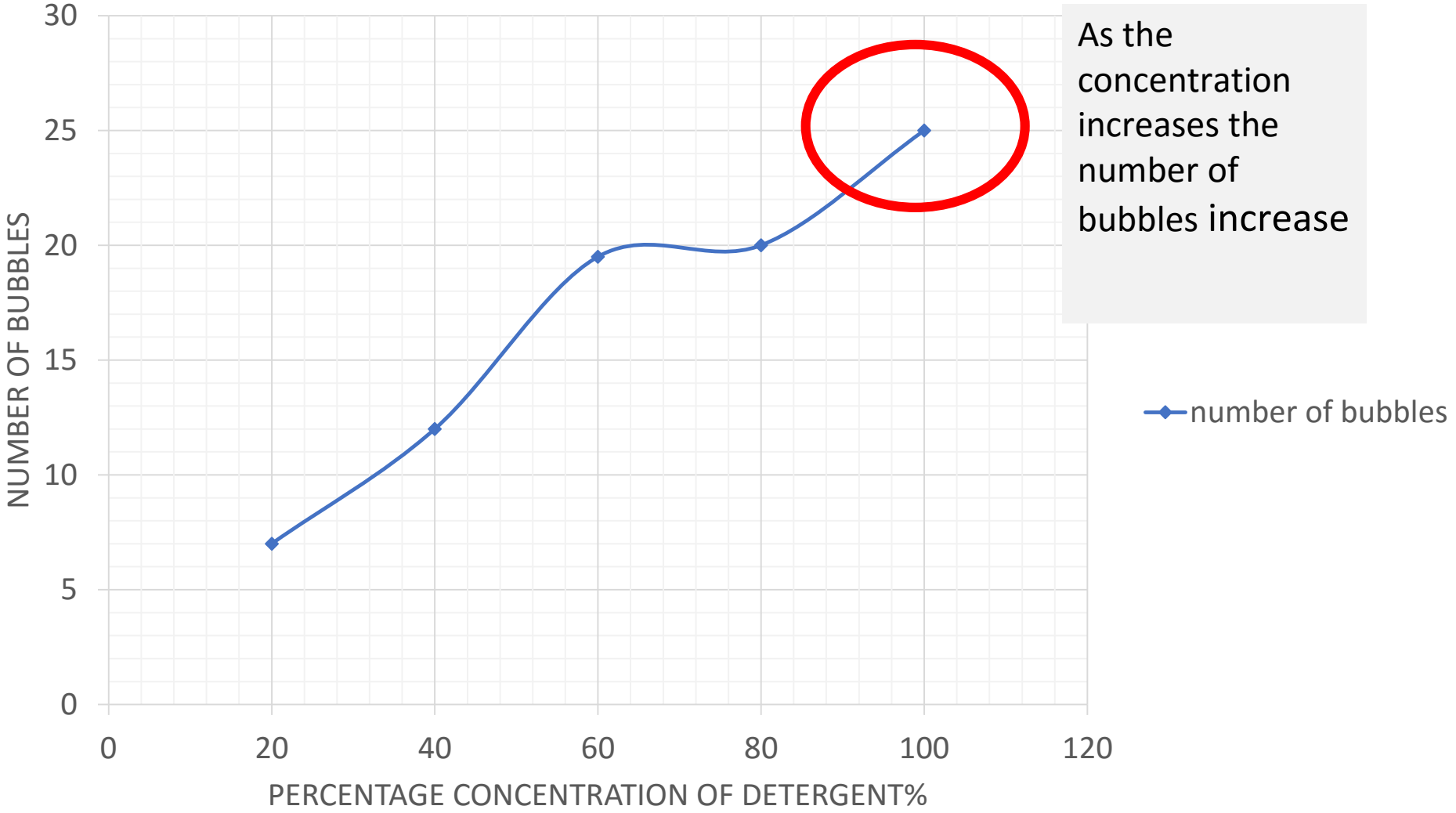
Preliminary Observations

Relation of concentration with number of bubbles

- Soap film is formed due to the surfactant.
- Increasing detergent concentration reduces surface tension and large number of bubbles are blown.
- Number of bubbles reaches peak around 100%concentration of detergent.
- 10% of surfactant exhibits a small number of bubbles.
- We took many concentrations and observe the number of bubbles.



Relation of concentration with number of bubbles



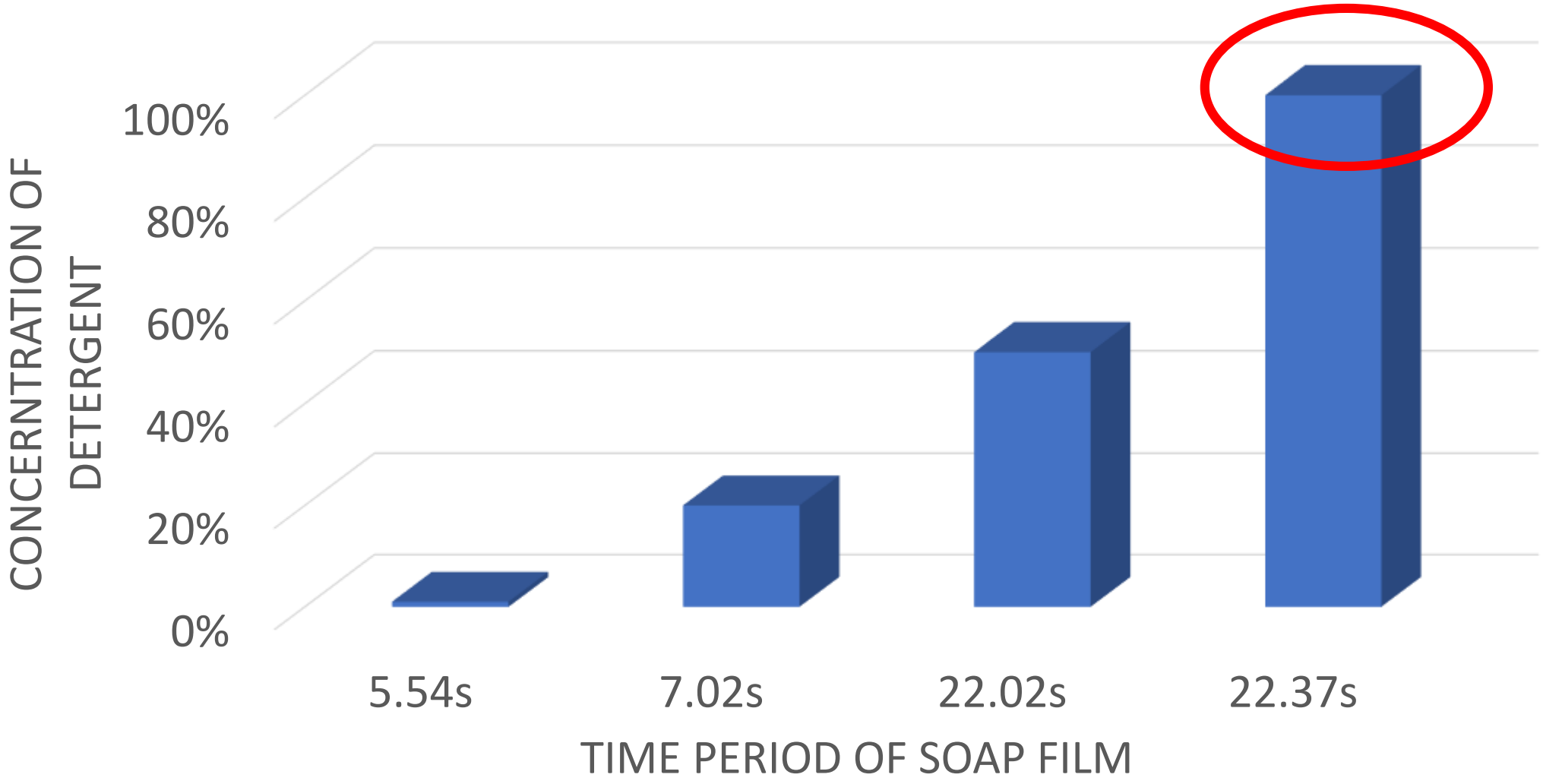
As the concentration increases the number of bubbles increase

Preliminary Observations

Relationship of concentration of soap film with duration of soap film

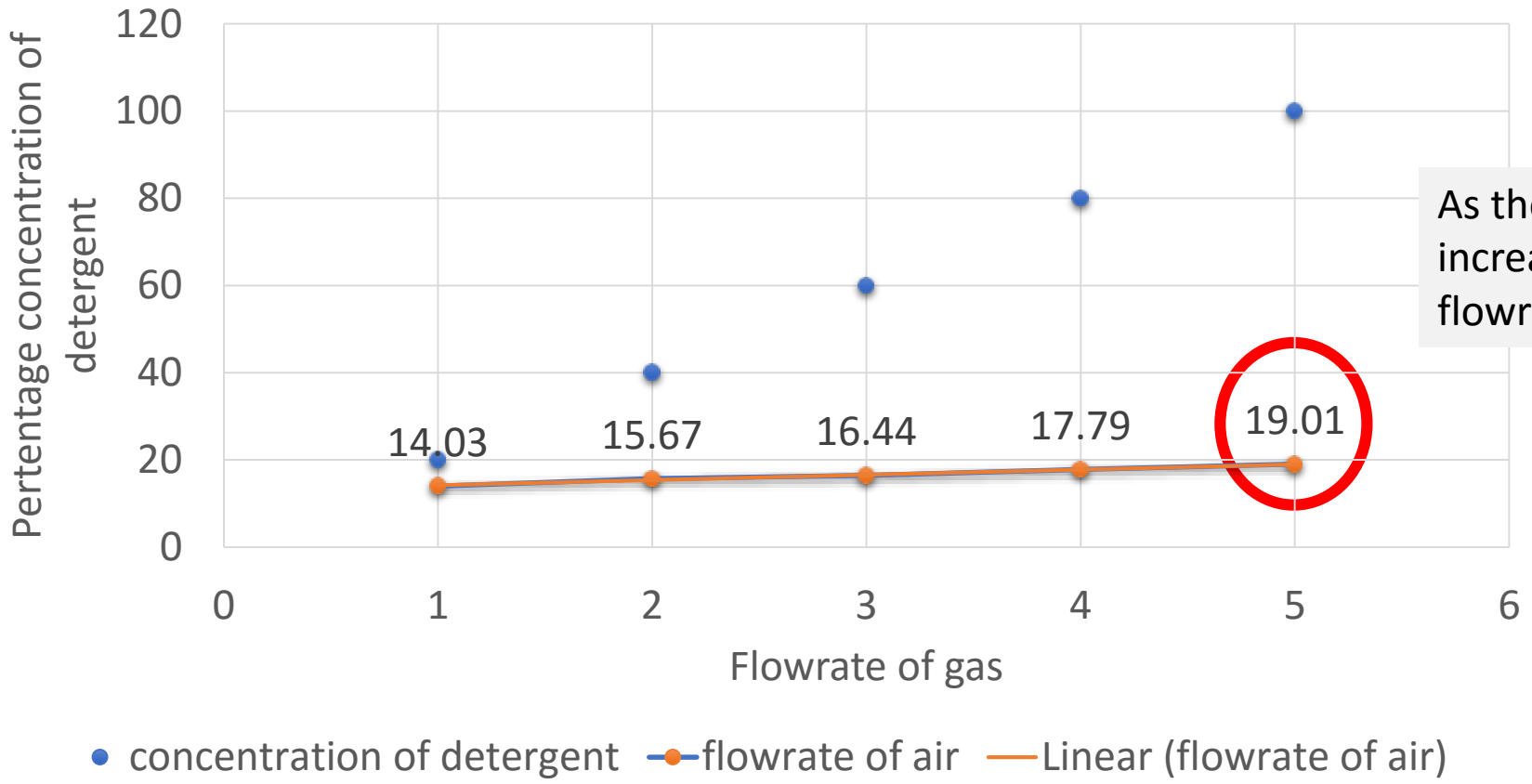
- The film formed from the solution with maximum concentration (80%surfactant and 20%water) exists for 19.5s(approx.)
- Whereas the film formed from the solution of (20% surfactant and 80% water) exists for 6.04s(approx.)
- Similarly the solution with concentration(50% surfactant and 50%) exists for long time 22.02s (approx.)and produce maximum bubbles per second.
- On other hand the film formed from the solution of minimum concentration (1%surfactant and 99%) lasts for 5.54s(approx.)

Relation of concentration with duration of soap film



Preliminary Observations

Relationship of concentration of soap film with flowrate of air

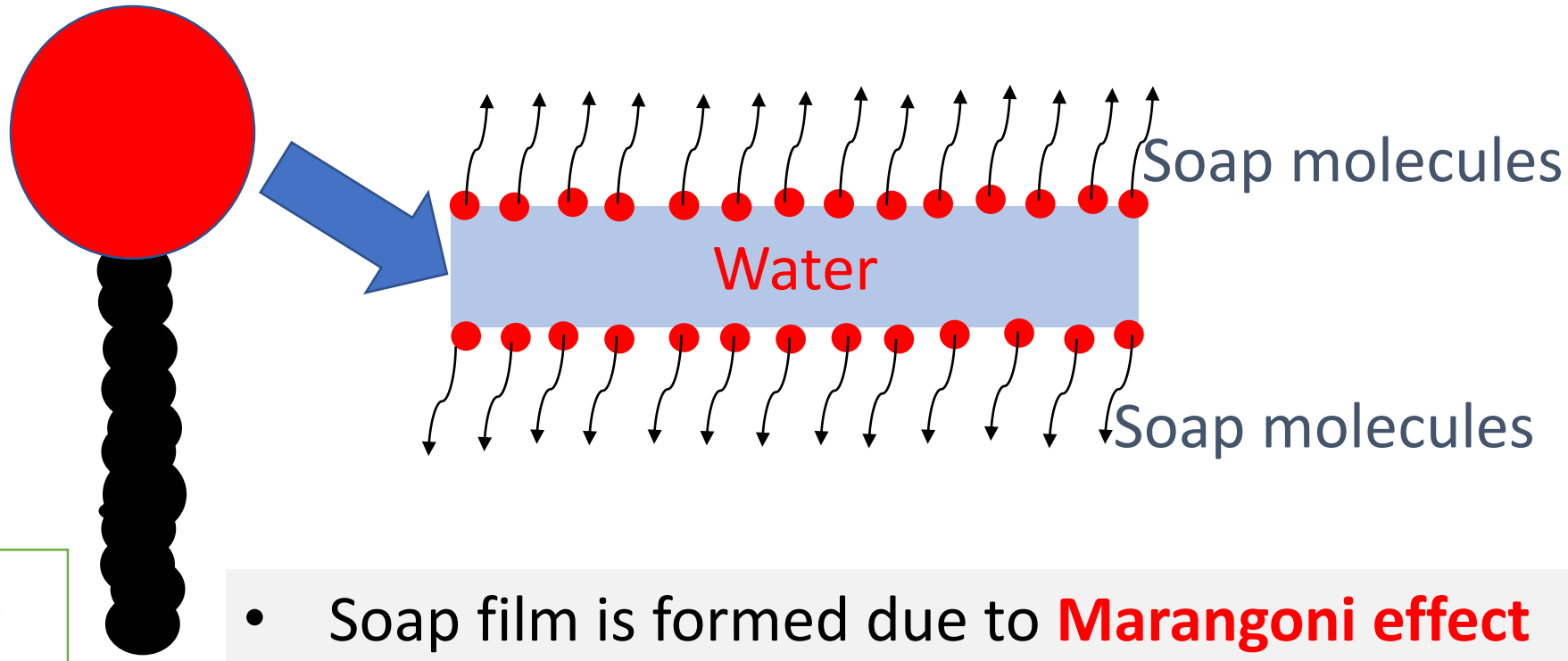


As the concentration increases the flowrate increases

Preliminary Observations

Proper surface tension is needed to produce soap bubbles

Hydrophilic head



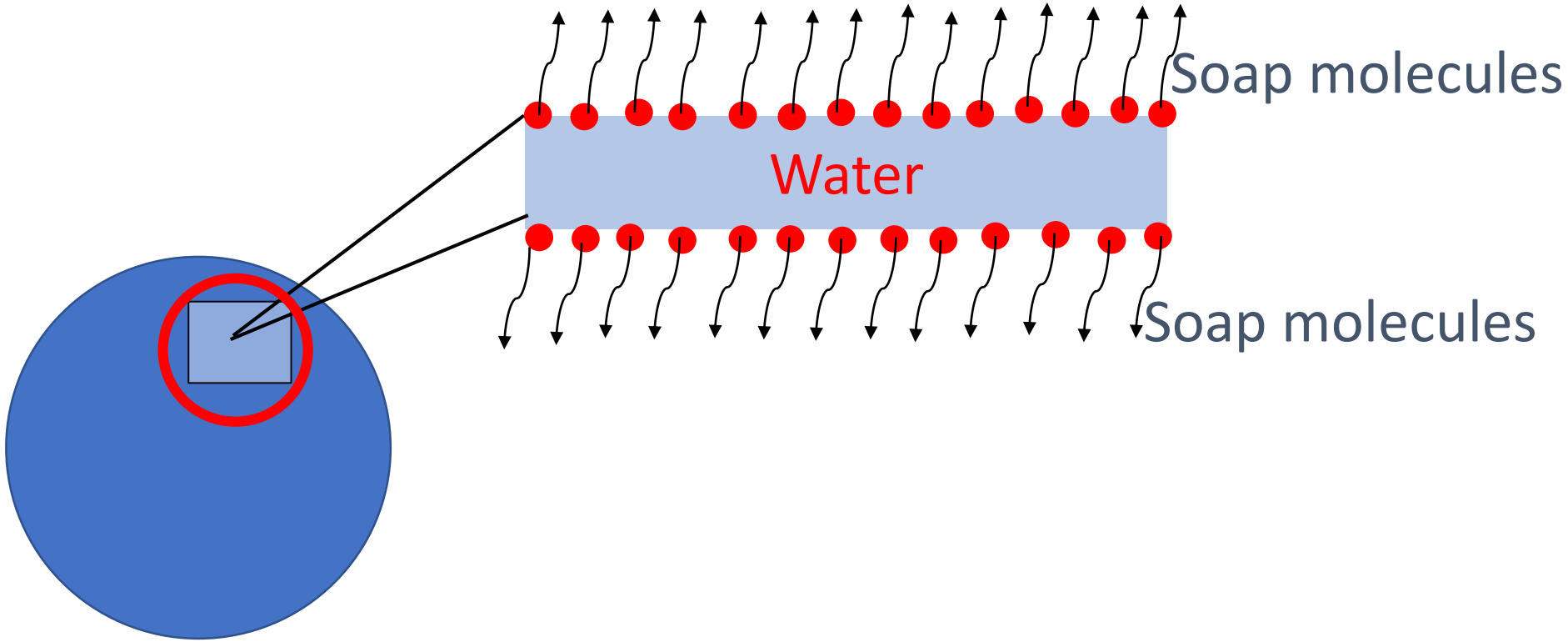
Hydrophobic tail

- Soap film is formed due to **Marangoni effect**
- Soap lower the surface tension of water

Preliminary Observations

Proper surface tension is needed to produce soap bubbles

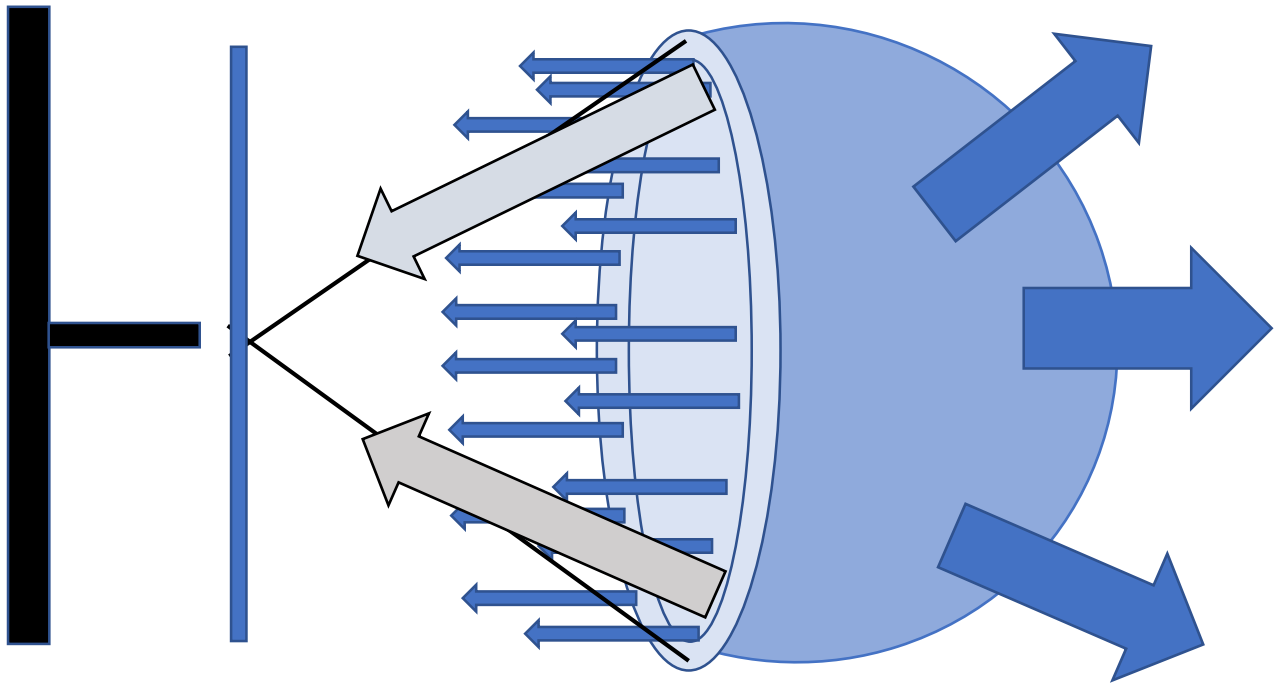
- Soap film is made from soap and water



Preliminary Observations

Bubble is always spherical

- Surface tension is pulling the water molecules in all directions and creating net inward force
- Hydrostatic equilibrium between the internal pressure and surface tension. One of it is trying to expand spherically the other to contract spherically.



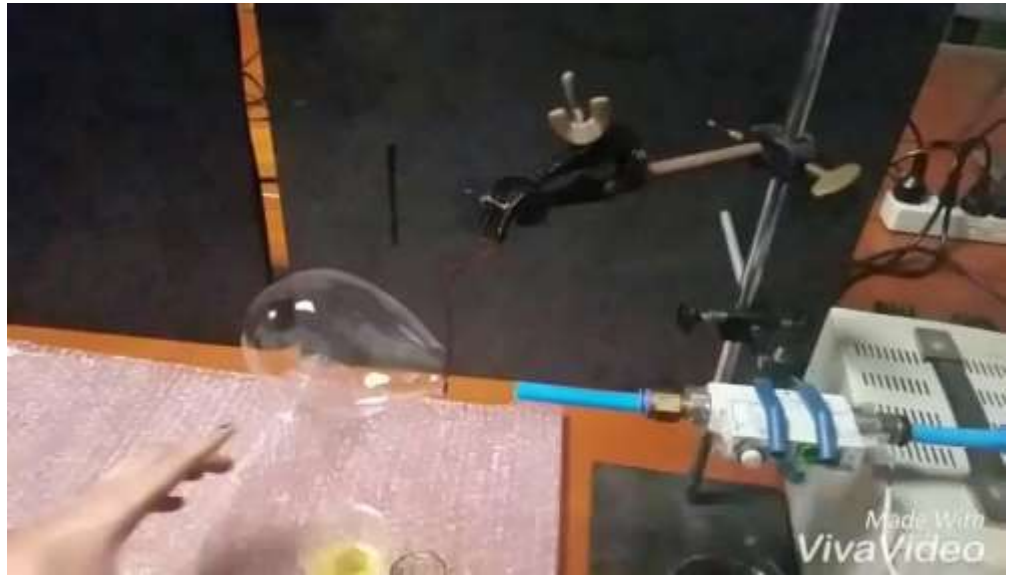
Surface tension

- Moreover the air pressure present inside the soap bubble opposes this and equilibrium is obtained Moreover the air pressure present inside the soap bubble opposes this and equilibrium is obtained

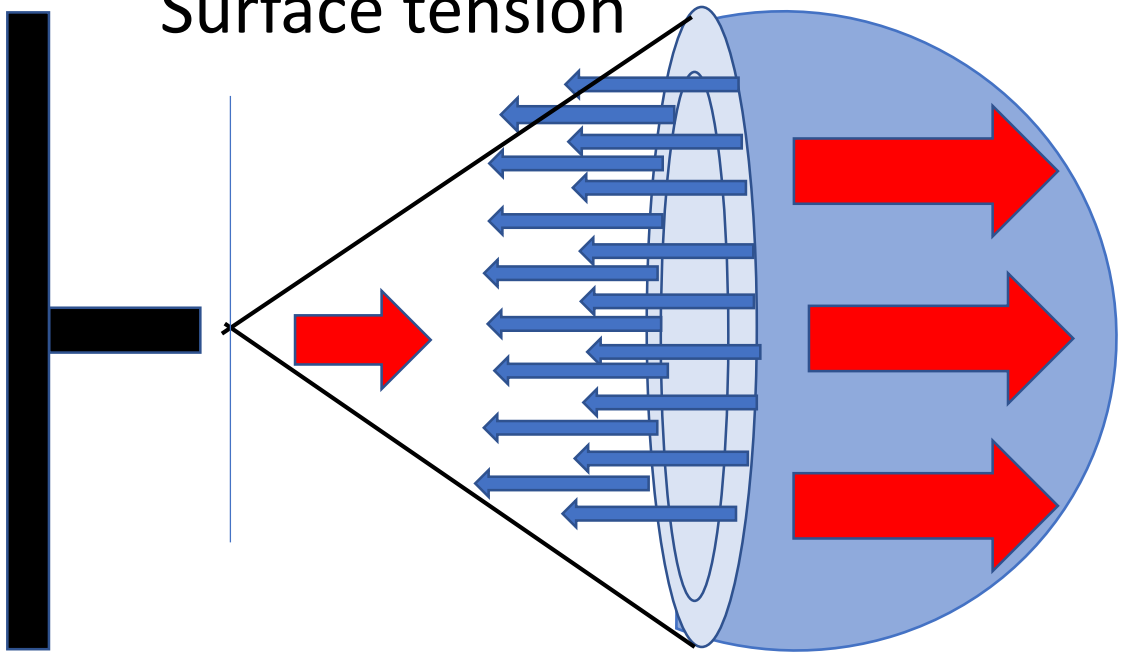
Popping of bubble

- Internal pressure increases

- Elastic membrane become thin



Surface tension



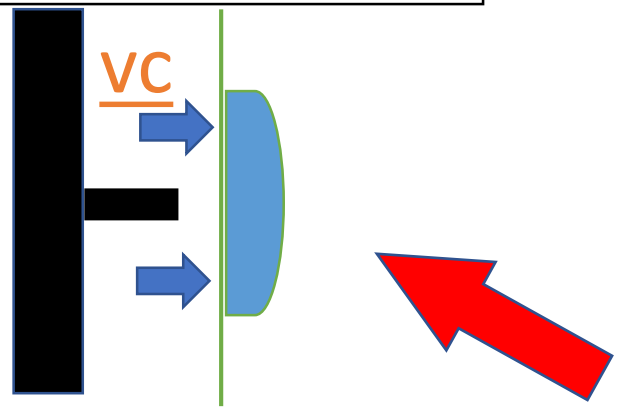
BURST

Hypothesis

Hypothesis 1

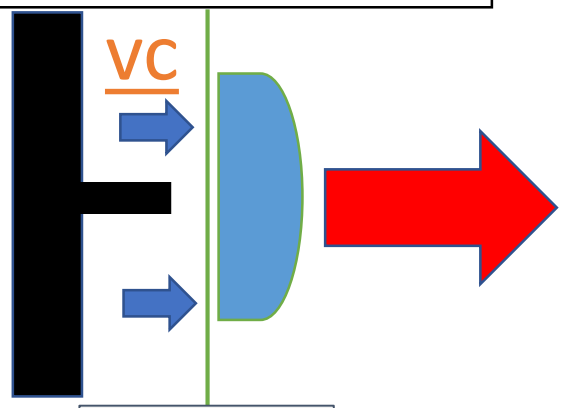
Soap bubbles are produced when the gas blowing velocity exceeds threshold vg (i.e. vg> vc)

BELOW THRESHOLD



Dimple is formed

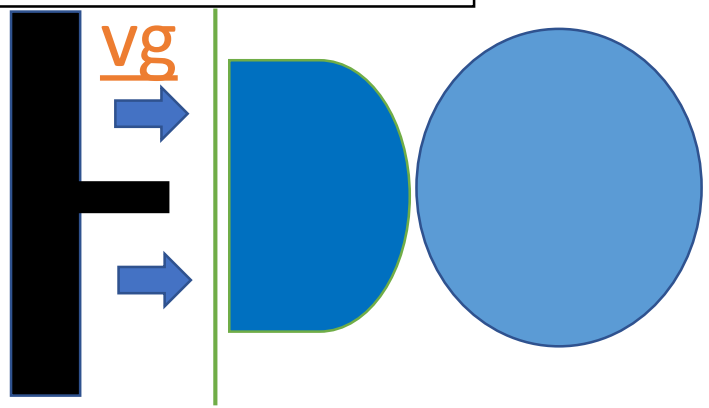
ABOUT THRESHOLD



vg< vc

It becomes greater as the speed increases

ABOVE THRESHOLD



vg> vc

Energy transport

$$1/2 p_g v_g^2 = 4\gamma / R_o$$

$$\delta = 0$$

Dynamic pressure of gas jet

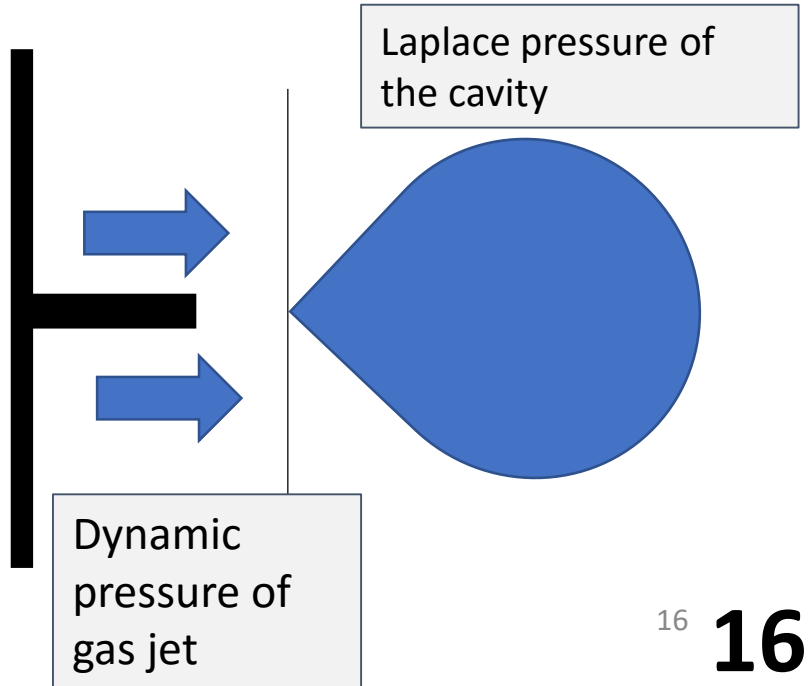
Laplace pressure of the cavity

P= density of gas(kgm^{-2})

$V_{g=}$ velocity of gas flow ($m.s^{-1}$)

γ= surface tension of the solution(N\m)

R_0 = radius of nozzle



Energy transport

$$vg = \sqrt{8\gamma / \rho g Ro}$$

for $\delta = 0$

$$\delta = 0$$

Threshold velocity

Distance between the soap film and nozzle

P= density of gas(kgm^{-2})

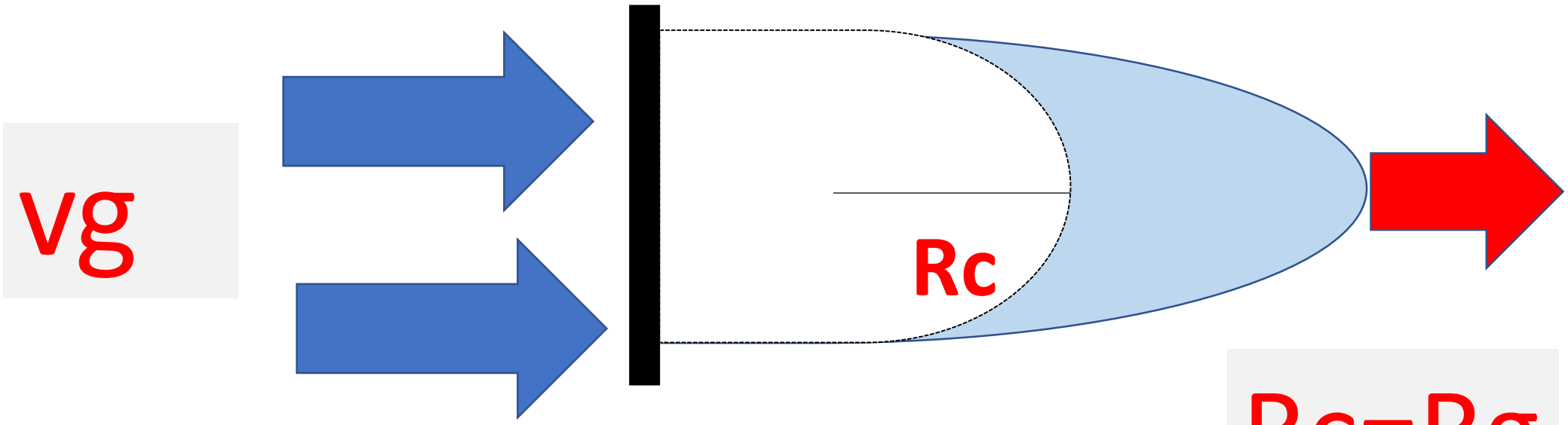
$V_{g=}$ velocity of gas flow ($m.s^{-1}$)

γ= surface tension of the solution(N\m)

R_0 = radius of nozzle

Hypothesis 2

First bubble is generated when the radius of ring become equal to the curvature of bubble (Rc=Rg)



Rc=curvature of bubble

Rg=radius of ring

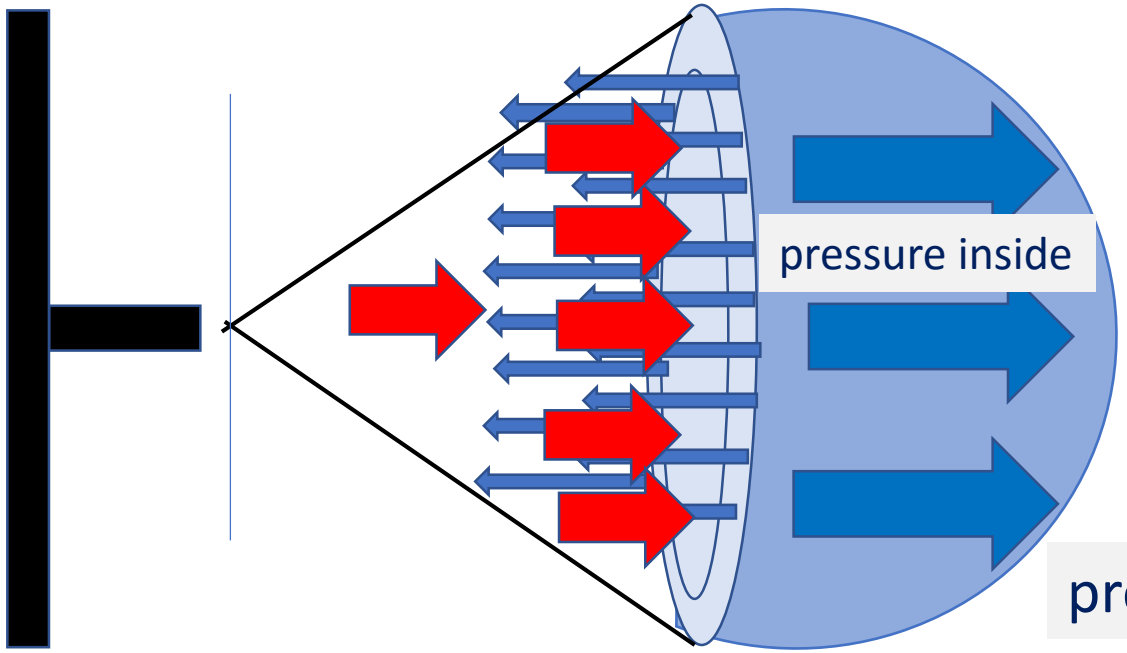
Hypothesis 3

Pressure inside the soap bubble is greater than the pressure outside the soap bubble(Pi>Po)

$$P(inside) - P(outside) = 4\chi/R$$

Pressure difference

Radius of the bubble



Pi=pressure inside
Po=pressure outside
R= radius of the bubble

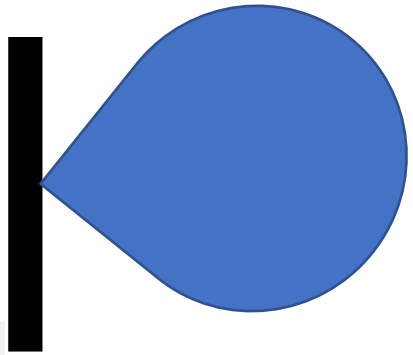
Hypothesis 4

productivity(p is the number of bubbles one soap film can produced per second.

$$P=\Pi R_0 v_g / 4/3\Pi R^{,3}$$

Number of bubbles single film can produced

Gas flow velocity



Ro= radius of the nozzle

R , =radius of bubble

$$N = p * \Delta t$$

Number of bubbles

T=time
P=number of bubbles one film can produced per second

Characteristics to be discussed with respect to parameters:

- Size of bubbles
- Number of bubbles(productivity)
- life span of bubbles

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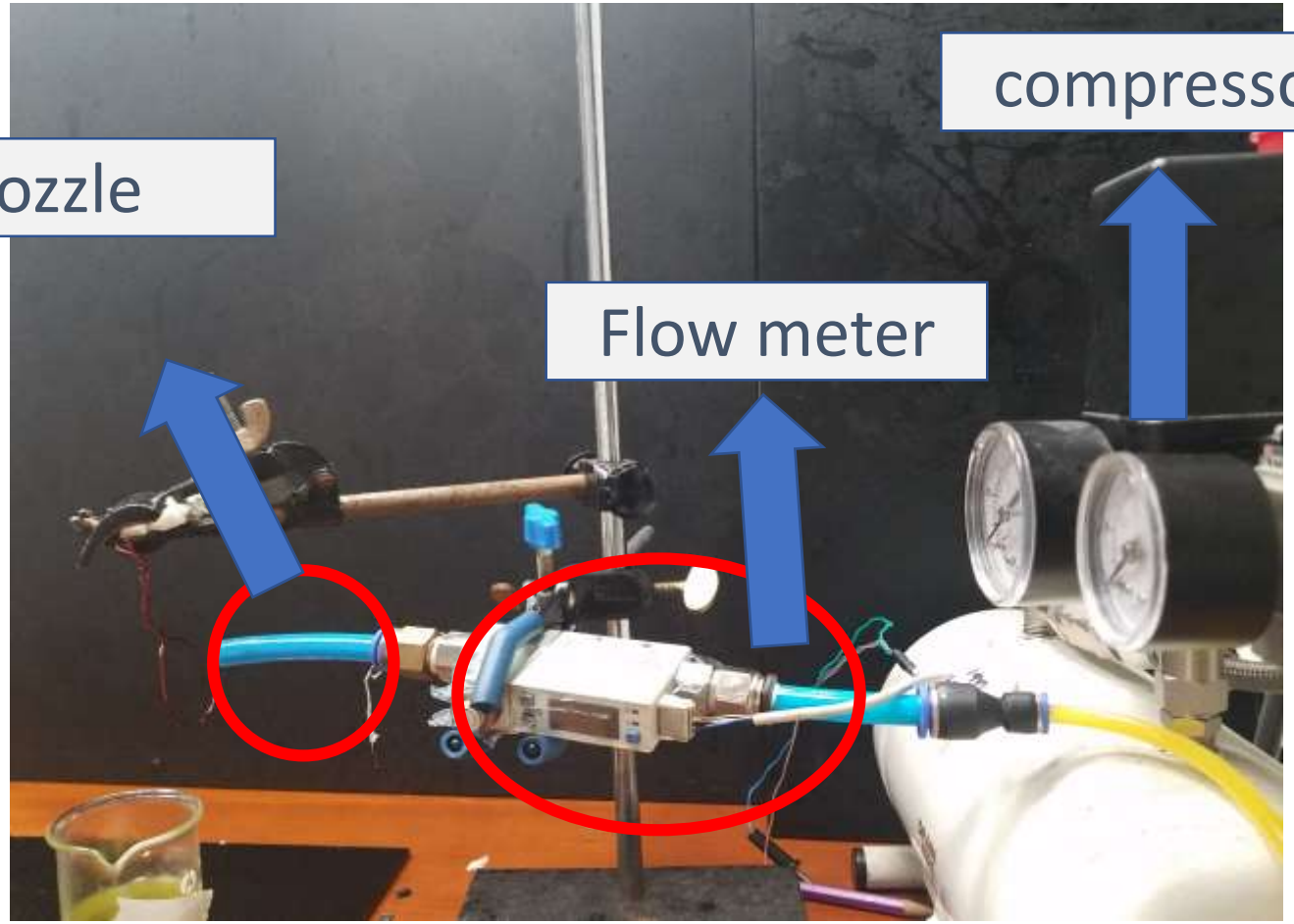
Parameters:

- Velocity of the gas
- Radius of the nozzle
- Distance of nozzle from the ring
- Surface tension of the solution
- Temperature of the solution
- Thickness of film

Experimental setup

Experimental setup



Experiment 1
Number of bubbles

- ✓ Flowrate of gas
- ✓ Surface tension of solution
- ✓ Temperature of soap film
- ✓ Thickness of soap film

Experiment 1
Number of bubbles
(single bubble analysis)

Control variables:

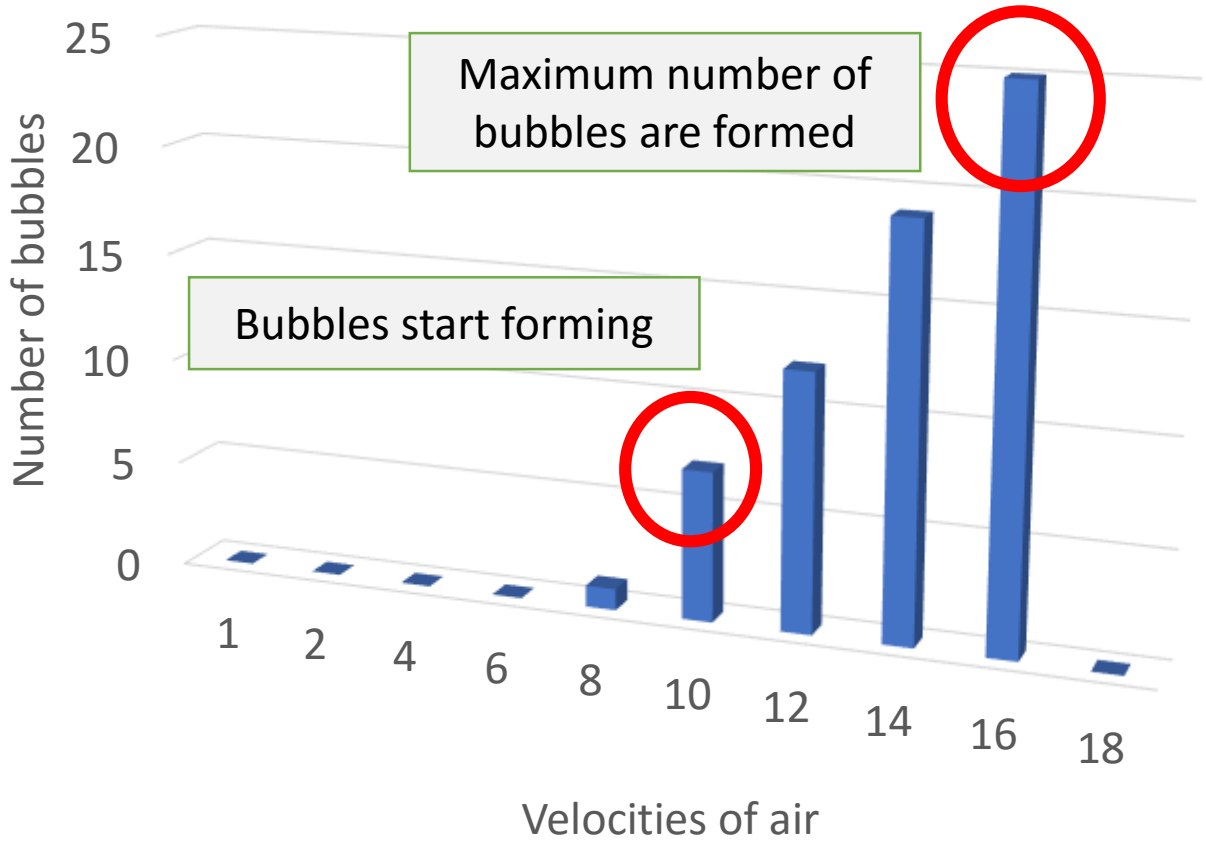
- Radius of ring : 1.6cm
- Diameter of nozzle:0.6cm
- Distance of nozzle from ring: **δ:**1.3cm
- Concentration of surfactant :50%
- Density of gas:1.225 kg/m^3

Independent variables:

- velocity of gas

✓ Dependent variable : number of bubbles

Experiment 1
Number of bubbles
(single bubble analysis)



Results :

- ✓ Bubbles start forming at 10L/m
- ✓ Maximum number of bubbles are formed at 14L/m

Experiment 2
Concentration and flowrate of air

Control variables:

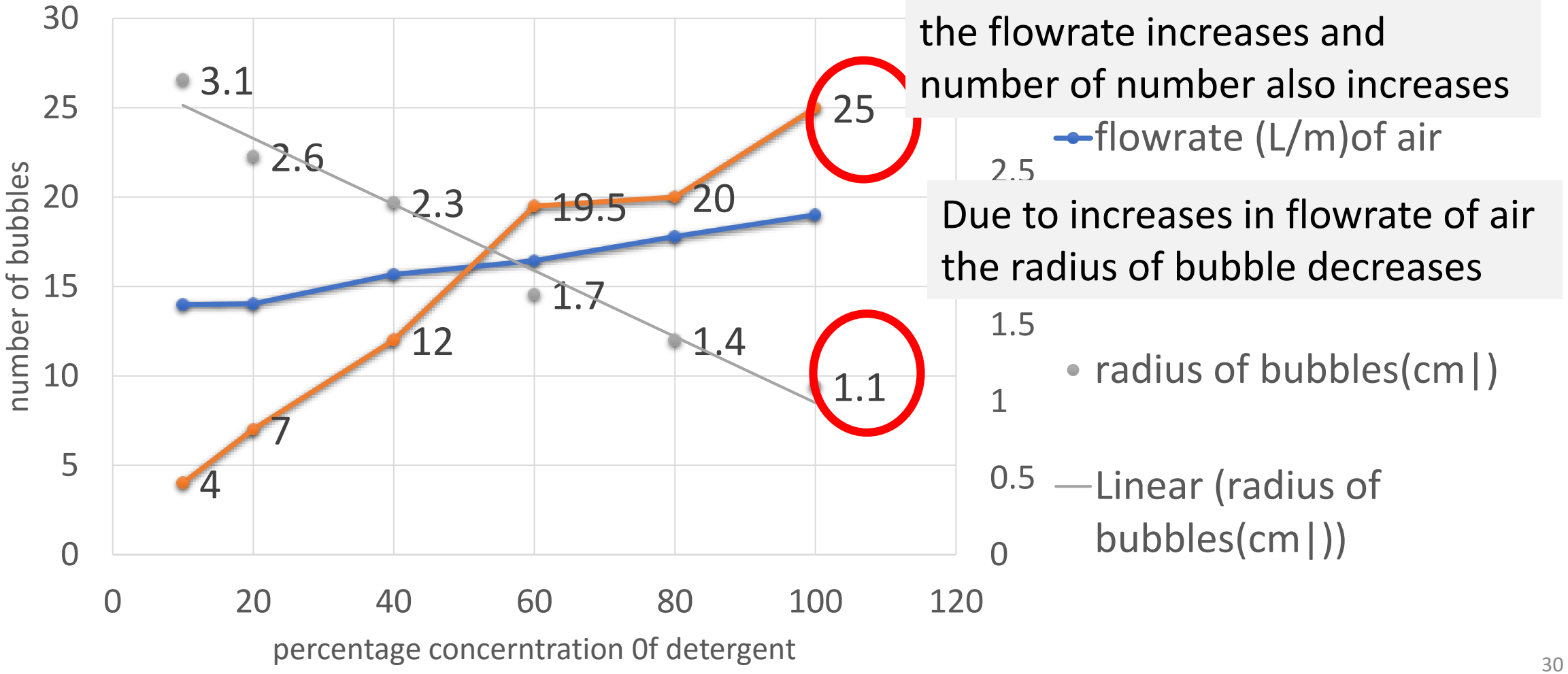
- Radius of ring : 1.6cm
- Diameter of nozzle:0.6cm
- Distance of nozzle from ring: **δ**:1.3cm
- Density of gas:1.225 kg/m^3

Independent variables:

- flowrate of gas
- Concentration of surfactant

✓ Analysis : number of bubbles and radius of bubbles

Experiment 2
Radius and Number of bubbles
(Different concentrations)



As the concentration increases the flowrate increases and number of number also increases

Due to increases in flowrate of air the radius of bubble decreases

Experiment 3
Temperature of soap film

Control variables:

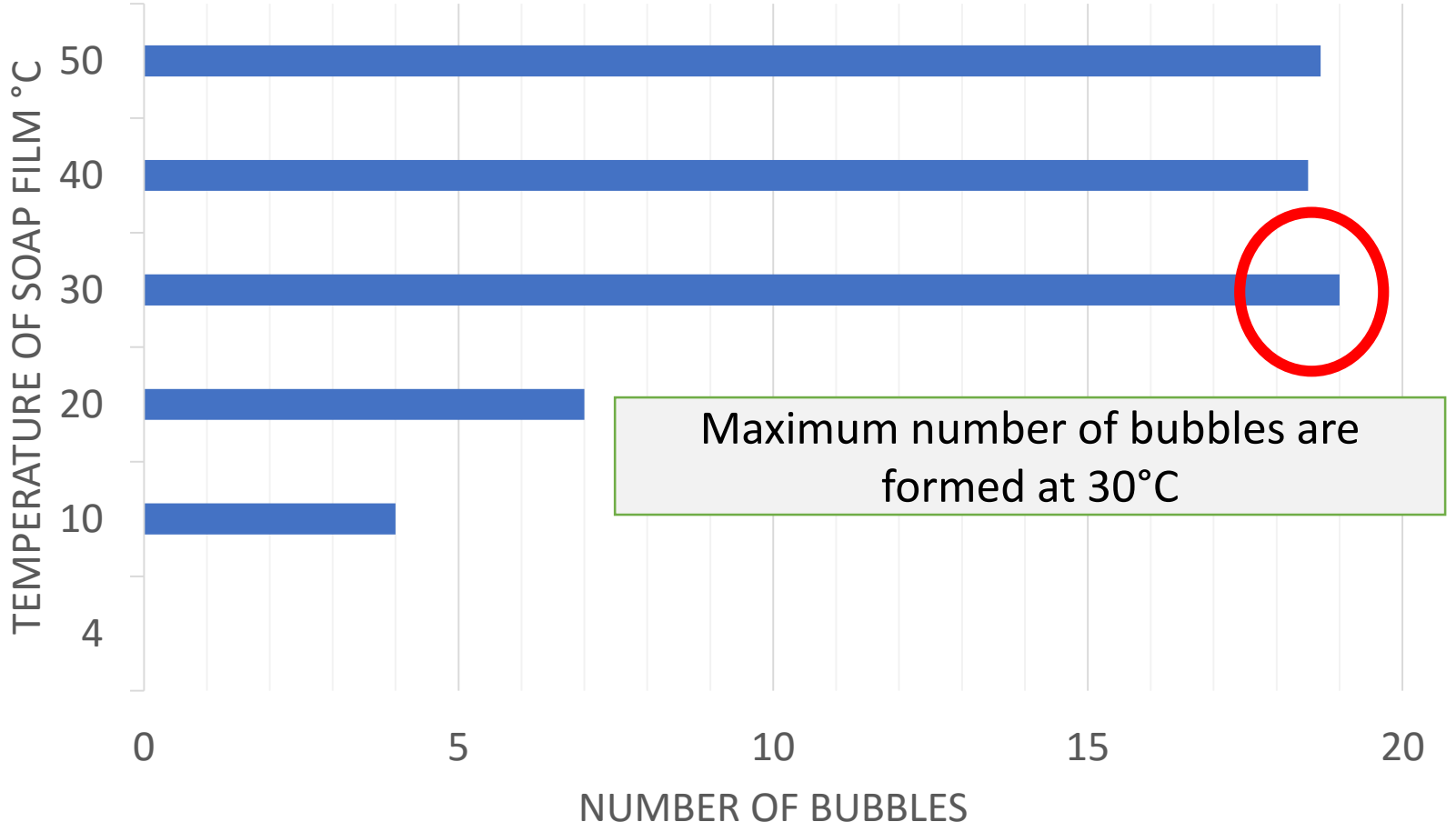
- Radius of ring : 1.6cm
- Diameter of nozzle:0.6cm
- Distance of nozzle from ring: **δ:**1.3cm
- Flow rate of gas:16.1(L/m)
- Concentration of detergent : 50%
- Density of gas:1.225 kg/m^3

Independent variables:

- Temperature of soap film

✓ analysis: number of bubbles

Experiment 3
Number of bubbles



Conclusion:

- ✓ Cohesive forces decrease with the increase of molecular thermal activity
- ✓ Surface tension decrease when temperature increases.

Experiment 4
Thickness of soap film

Control variables:

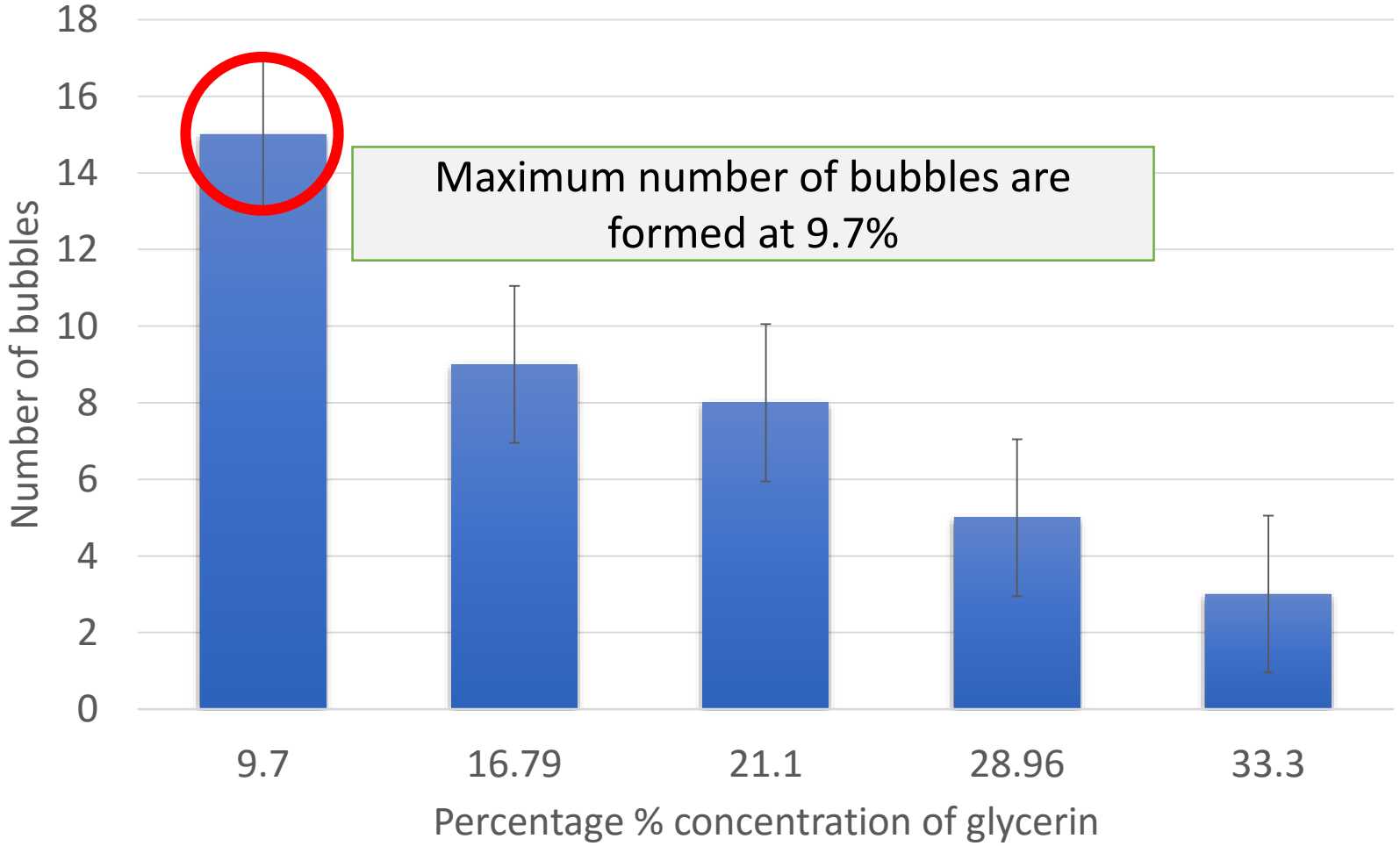
- Radius of ring : 1.6cm
- Diameter of nozzle:0.6cm
- Distance of nozzle from ring: **δ**:1.3cm
- Density of gas:1.225 kg/m^3

Independent variables:

- Amount of glycerin

✓ Analysis : number of bubbles

Experiment 4
Thickness of soap film



Conclusion:

- ✓ Higher the concentration of glycerin lower the number of bubbles

Experiment 5
Size of bubbles at different flowrates

Control variables:

- Radius of ring : 1.6cm
- Diameter of nozzle:0.6cm
- Distance of nozzle from ring: **δ**:1.3cm
- Density of gas:1.225 kg/m^3

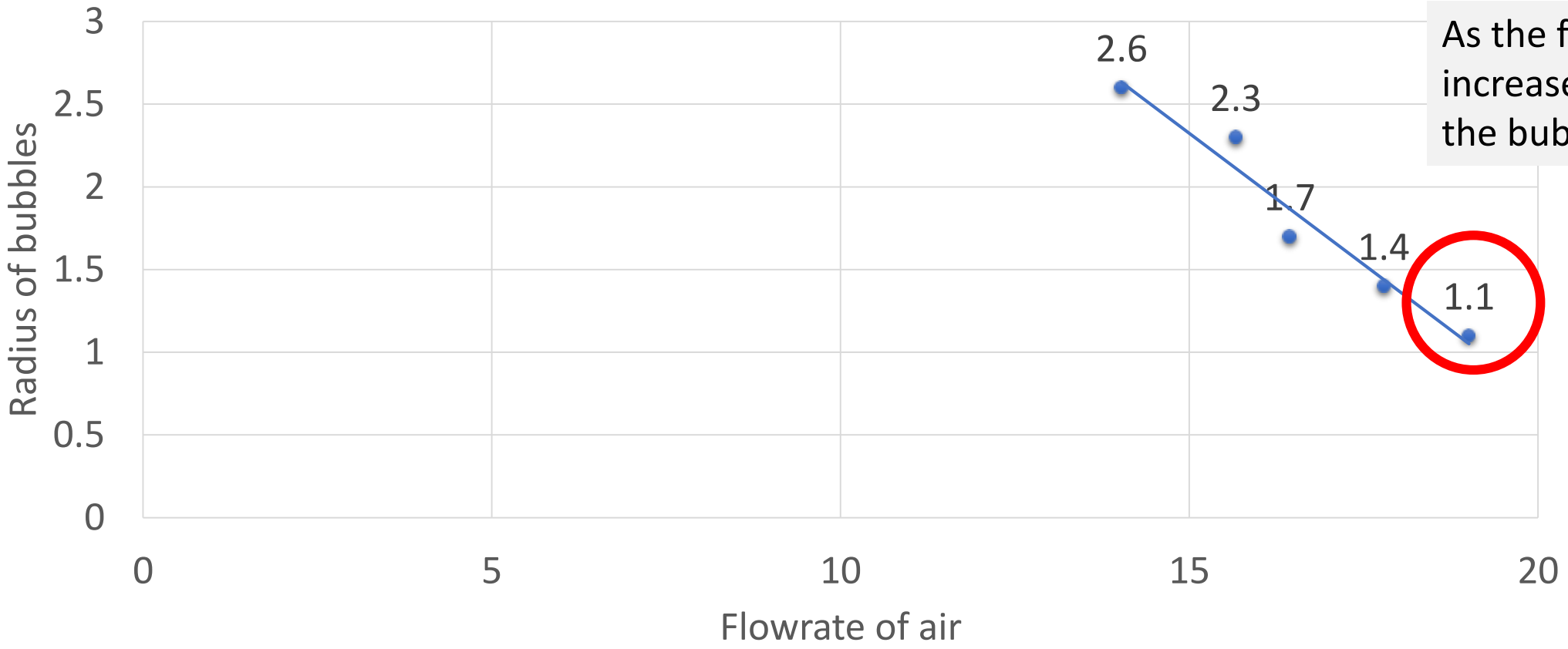
Independent variables:

- Flowrate of gas

✓ Analysis :size of bubbles

Experiment 5

Size of bubbles at different flowrates

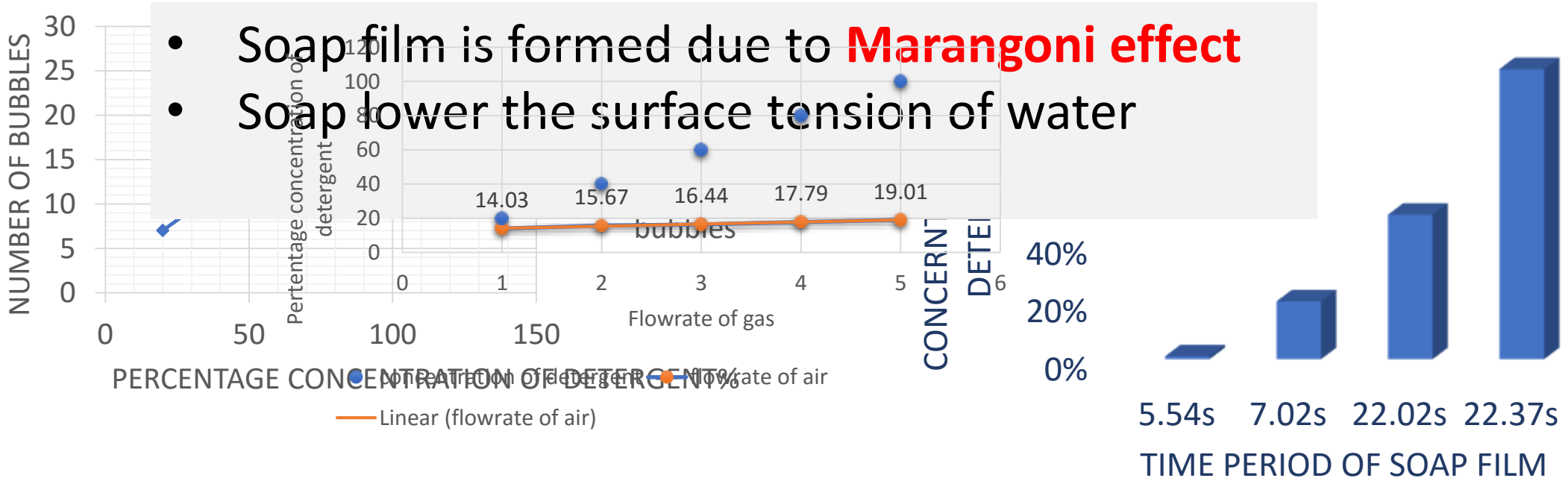


As the flowrate increases the radius of the bubble decreases

conclusion

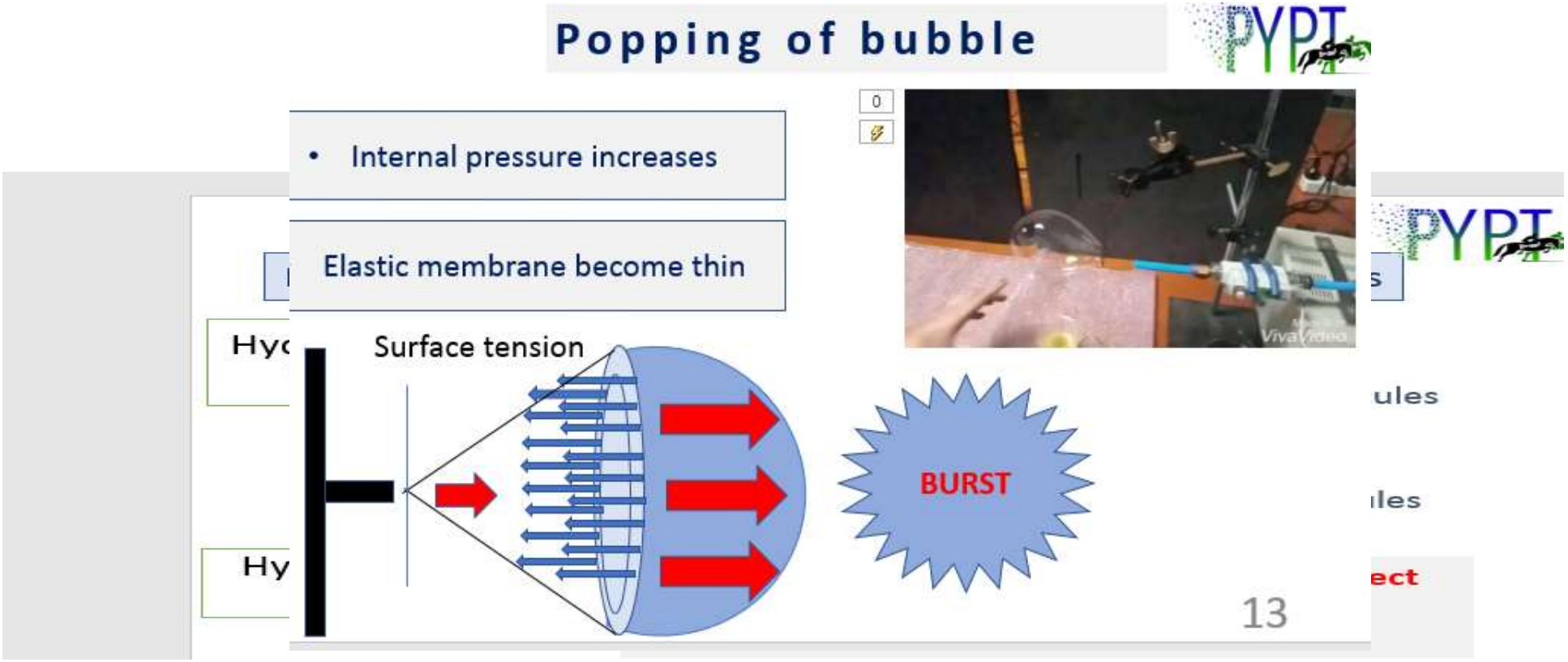
- ✓ Relationship between the concentrations of detergents and the number of bubbles produced from single soap film and the duration of soap film
- ✓ How and why the soap film is produced and the role of surface tension in bubble formation
- ✓ Concentration of detergent and its affects on flowrate of gas

- Soap film is formed due to **Marangoni effect**
- Soap lower the surface tension of water



conclusion

- ✓ Surfactant and its role in formation of bubble
- ✓ Popping of bubble



conclusion

- ✓ Discuss some hypothesis above the bubble formation

Energy transport

1 3

$1/2 p_g v_g^2 = 4\gamma / R_o$

2 Dynamic pressure of gas jet

4 Laplace pressure of the cavity

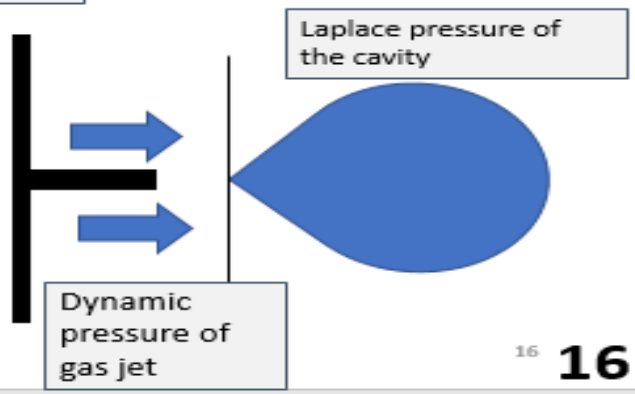
$\delta = 0$

P= density of gas(kgm^{-2})

$V_{g=}$ velocity of gas flow ($m.s^{-1}$)

γ= surface tension of the solution(N\m)

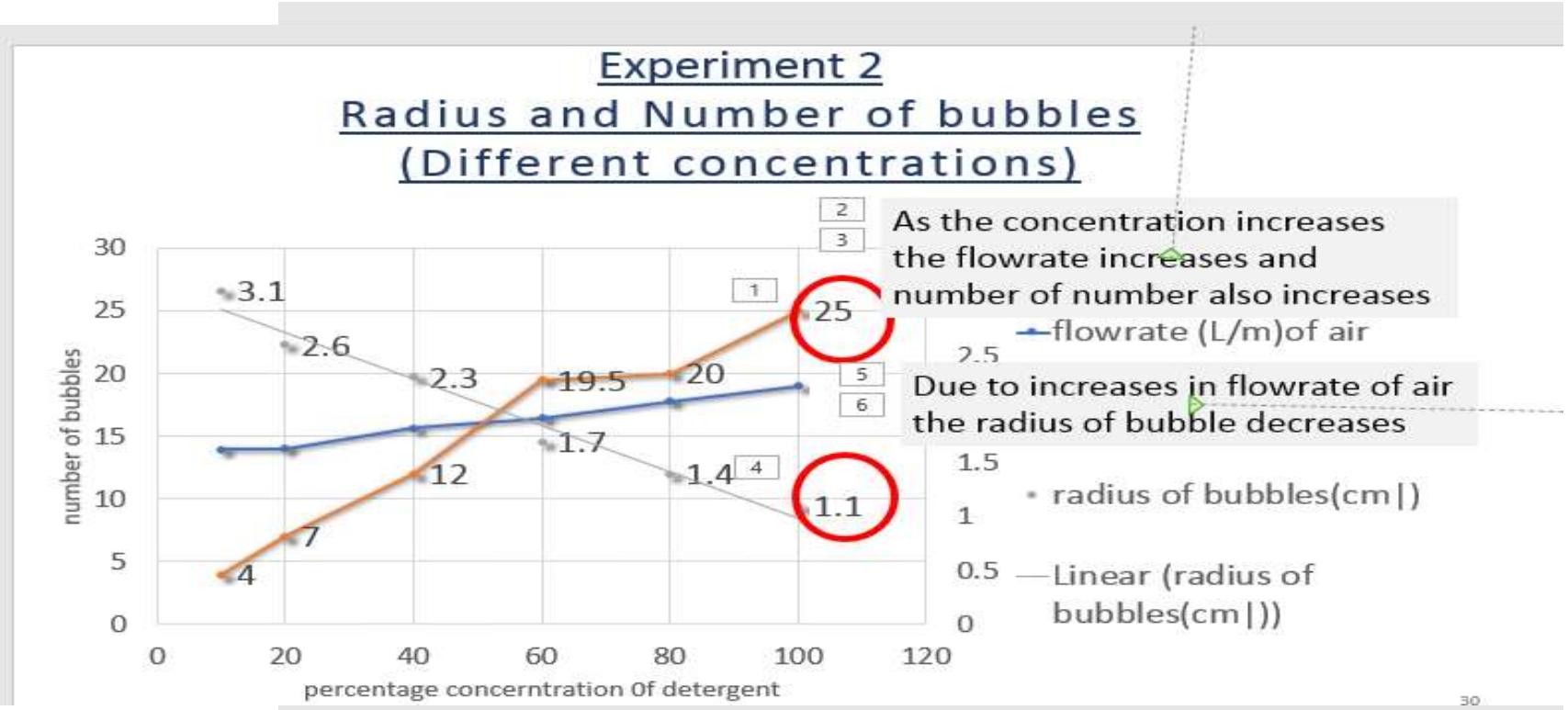
R_o = radius of nozzle



16 16

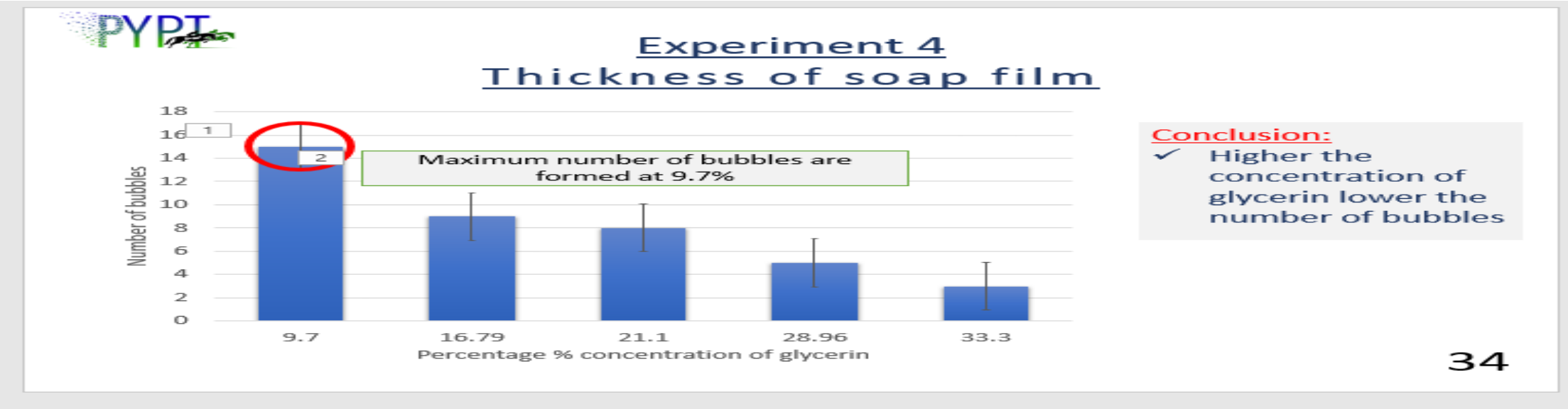
conclusion

- ✓ The relationship between the velocity of jet and the pressure inside the bubble
- ✓ Characteristics of bubbles with respect to parameters
- ✓ The radius and the number of bubbles at different concentration and flowrate



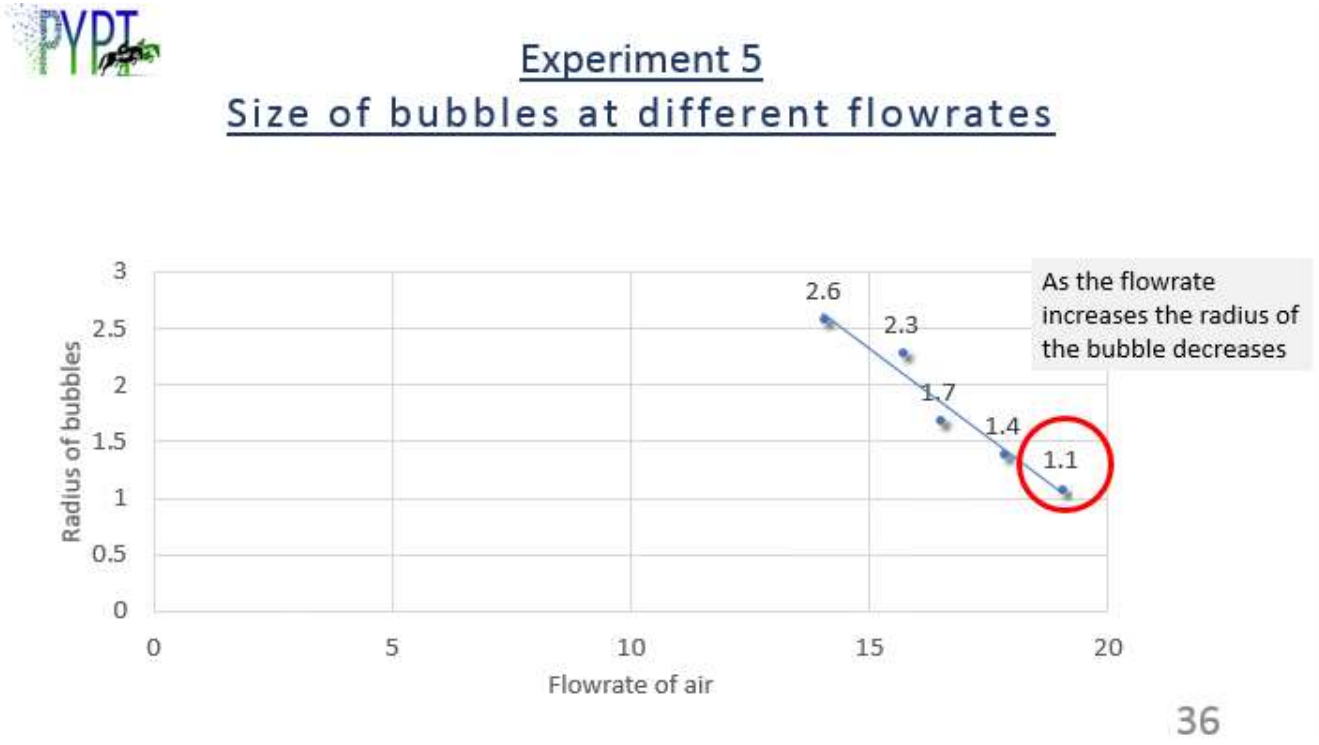
conclusion

- ✓ Number of bubbles by varying the temperature of soap film
- ✓ The relation between the thickness of soap film and the number of bubbles



conclusion

- Radius of bubbles on different flow rates

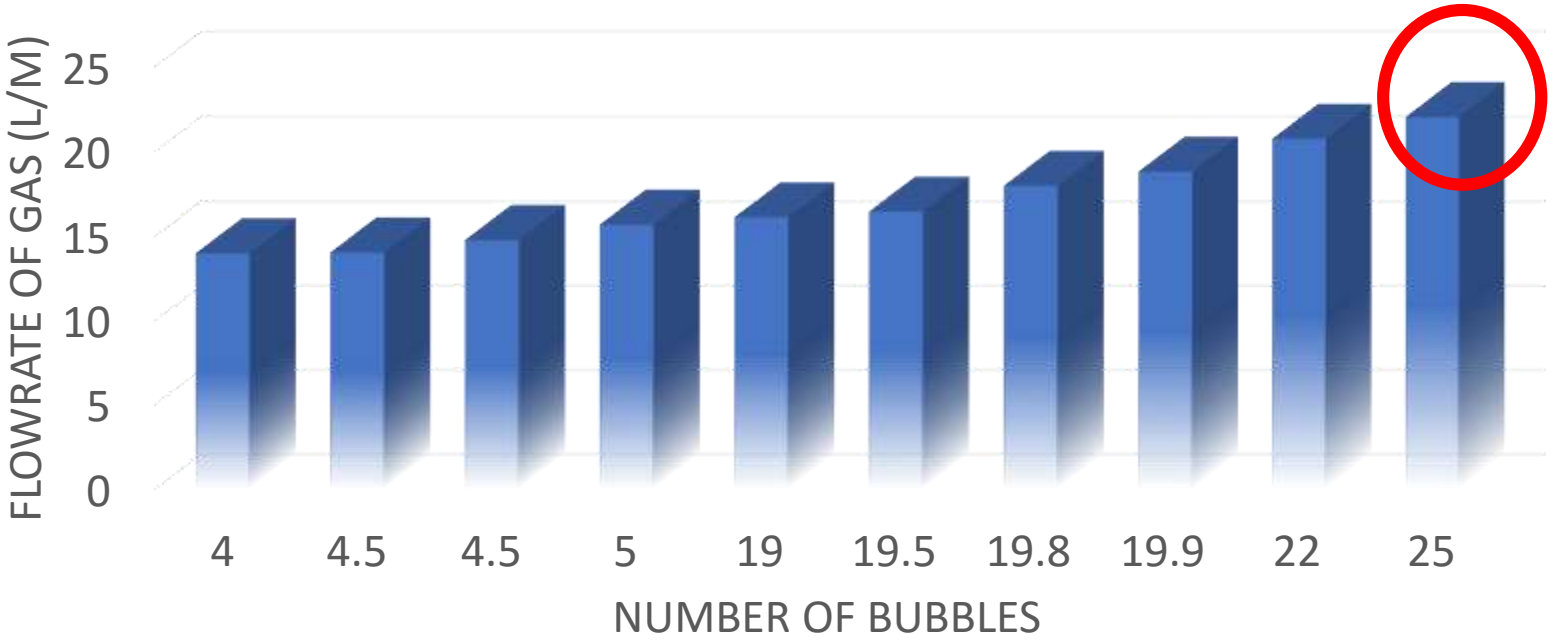


THANK YOU

concentration	flowrate	radius	bubbles
100	19.01	1.1	25
80	17.79	1.4	21
60	16.44	1.7	19.5
40	15.67	2.3	12
20	14.03	2.6	7
10	13.98	3.1	4

Experiment 1
Number of bubbles

Maximum number of bubbles are formed22.01(L/m) (100% concentration)

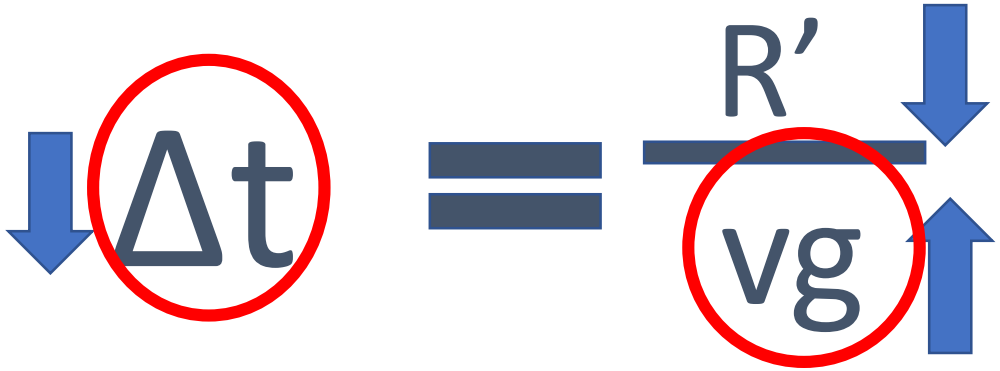


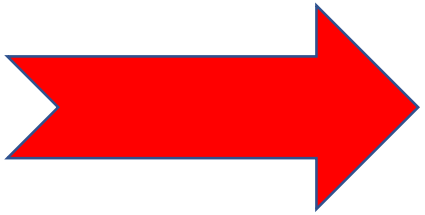
Conclusion:

- ✓ Higher the concentration greater the bubbles blown out

Hypothesis 5

Duration or stability of soap bubbles(amount of time in which bubbles are produced from the film)





UNSTABLE

T=amount of time that film keep generating bubbles
Vg=gas flow velocity