REDUCTION OF GLOBAL WARMING/ CLIMATE CHANGE THROUGH CARBON DIOXIDE PHOTOSYNTHESIS USING NOVEL HIGH PERFORMANCE AEROGEL PHOTOCATALYSTS

BY: YOSRY ATTIA

TAASI CORPORATION/ THE ATTIA APPLIED SCIENCES, INC.; WWW.TAASI.COM

548 WEST CENTRAL AVENUE, DELAWARE, OHIO 43015; TEL:740-362-3071

[y.attia@taasi.com]

FOR OVER 30 YEARS, TAASI CORPORATION HAS BEEN A WORLD LEADER IN THE DEVELOPMENT OF NOVEL AEROGEL MATERIALS AND TECHNOLOGIES FOR DIVERSE APPLICATIONS IN OVER 50 INDUSTRIAL SECTORS.

GLOBAL WARMING/ CLIMATE CHANGE PROBLEM

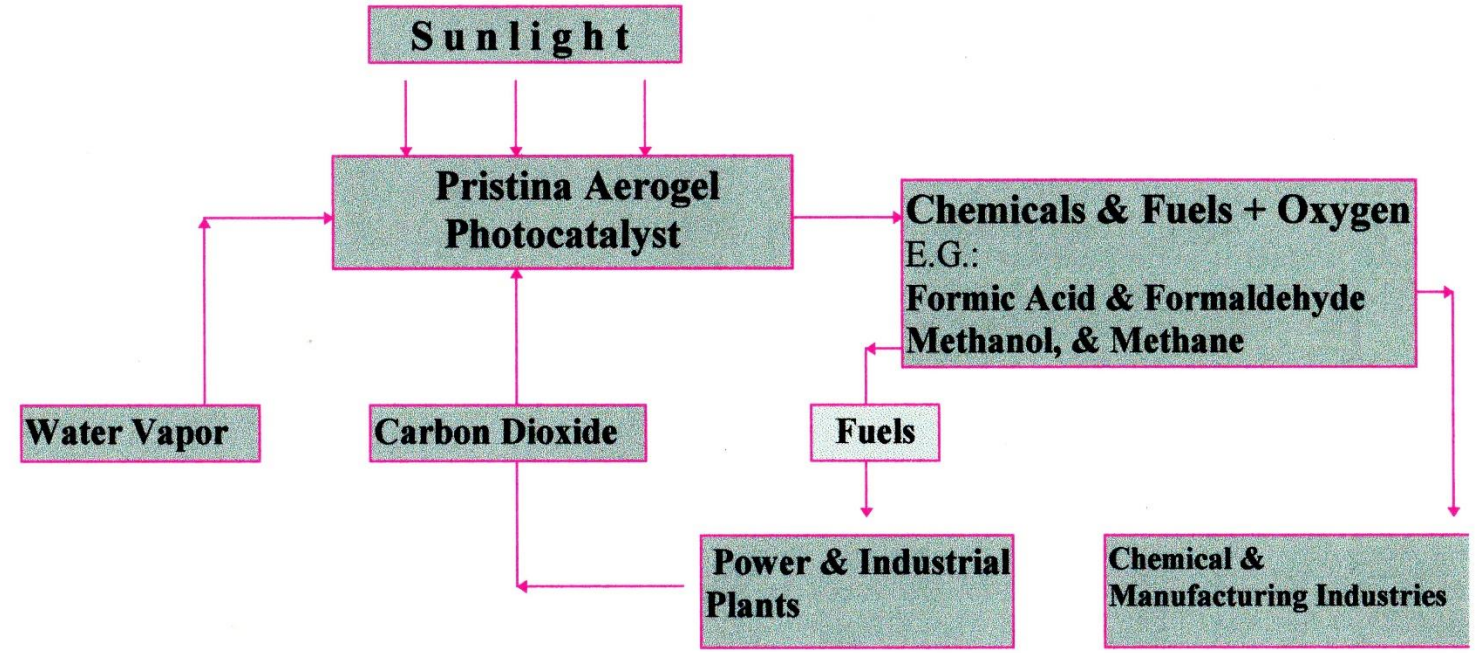
- **THE CAUSE OF GLOBAL WARMING/ CLIMATE CHANGE HAS BEEN LARGELY ATTRIBUTED TO THE NET INCREASE IN CARBON DIOXIDE (CO_2) GAS EMISSIONS INTO THE ATMOSPHERE DUE TO A DISEQUILIBRIUM BETWEEN PRODUCTION AND CONSUMPTION OF CARBON DIOXIDE.**

- **THIS DISEQUILIBRIUM IS A RESULT OF CONTINOUS GROWTH OF HUMAN POPULATION AND ACTIVITIES THAT PRODUCE CARBON DIOXIDE, WITH CORRESPONDING DIMINISHING OF LAND FORESTATIONS THAT CONSUME CARBON DIOXIDE.**

POTENTIAL SOLUTION OF GLOBAL WARMING: PHOTOSYNTHESIS USING TAASI'S PRISTINA AEROGEL PHOTOCATALYSTS

- **OPTION-1:** CONTACTING CARBON DIOXIDE [CO2] AND WATER VAPOR WITH PRISTINA AEROGEL PHOTOCATALYST, ACTIVATED BY LIGHT TO PRODUCE USEFUL CHEMICALS AND OR FUELS, PLUS OXYGEN.
- **OPTION-2: SAME AS OPTION-1,** BUT INTRODUCE NITROGEN GAS [N2] TO THE MIX, TO PRODUCE AMINO ACIDS [PROTEINS] FOR USE AS FOOD NUTRIENTS AND THUS HELP ELIMINATE BOTH WORLD HUNGER AND GLOBAL WARMING AT THE SAME TIME.
- **DR. YOSRY ATTIA WAS THE FIRST TO CONCEIVE AND PROPOSE THE "ENGINEERED PHOTOSYNTHESIS USING AEROGEL PHOTOCATALYSTS APPROACH FOR THE EMISSION CONTROL OF CARBON DIOXIDE IN THE MID 1990'S.**
- **RECENT DESIGN CONCEPTS COMBINING SOLAR AND ELECTRIC LIGHT AND SCALEABLE TO LARGE AND SMALL SIZES, WILL ALSO EMPOWER INDIVIDUAL HOUSEHOLDS TO PARTICIPATE IN SOLVING THE GLOBAL WARMING PROBLEM.**

TAASI'S ENGINEERED PHOTOSYNTHESIS



MECHANISMS OF PHOTOCATALYTIC REDUCTION OF CARBON DIOXIDE

1-CARBON DIOXIDE + WATER VAPOR:

PHOTO-GENERATED ELECTRONS (e–) AND HOLES (h†) FROM PHOTOCATALYST EXCITATION BY LIGHT, FORM HIGHLY REACTIVE FREE RADICALS SUCH AS: $CO^{\cdot}$, $OH^{\cdot}$, PRODUCING FORMIC ACID [HCOOH] PLUS OXYGEN.

- **FORMIC ACID MAY BE CONVERTED TO FORMALDEHYDE PLUS OXYGEN:**

$HCOOH + 2e^{-} = HCOH + ½ O2$.

FURTHER REDUCTIONS MAY LEAD TO PRODUCTION OF METHANOL AND METHANE, PLUS OXYGEN.

2-CARBON DIOXIDE + WATER + NITROGEN:

IN ADDITION TO ABOVE FREE RADICALS, FORMATION OF $NCO^{\cdot}$ AND $ON\text{-}NCO^{\cdot}$ FREE RADICALS RESULT IN A POLYCONDENSATE CONTAINING AMINO ACIDS, SUCH AS ARGININE, LYSINE, HISTIDINE, ETC.

WHY TAASI AEROGEL PHOTOCATALYSTS

TAASI'S PROPRIETARY COMPOSITION OF AEROGEL PHOTOCATALYSTS HAVE THE POTENTIAL OF MAXIMIZING CONVERSION RATES AND OVERALL PHOTOSYNTHESIS EFFICENCY DUE TO THE FOLLOWING ADVANTAGES:

- **VERY HIGH VOLUME POROSITY [~90% OR HIGHER], AND VERY HIGH SURFACE AREA [E.G., 550-760 METER SQUARE PER GRAM].**
- **HIGH CAPACITY FOR HARVESTING LIGHT ENERGY. DESIGN COMPOSITION ALLOWS FOR CAPTURE OF LIGHT WAVE LENGTHS 300-800 NM. IMPROVED ELECTRON TRANSFER EFFICIENCY.**
- **EITHER DAYLIGHT ONLY, OR ELECTRIC LIGHT ONLY, OR A COMBINATION OF BOTH MAY BE USED WITH TAASI'S AEROGEL PHOTOCATALYSTS. ONLY 0.1 MILLIWATT PER SQUARE CENTIMETER [1.0 W/M2] IS NEEDED TO ACTIVATE THE PHOTOCATALYST AND INITIATE PHOTOCATALYTIC REACTIONS.**
- **TAASI SUCCESSFULLY DEVELOPED AEROGEL PHOTOCATALYTIC AEROGEL TECHNOLOGIES FOR (A) DESTRUCTION REMOVAL OF CYANIDE FROM A COKE PLANT'S WASTE WATER; AND (B) DESTRUCTION REMOVAL OF BENZENE FROM WATER, WITH OVER 95% REMOVAL IN EACH CASE.**

ENGINEERING APPLICATIONS OF THE PHOTOSYNTHESIS PROCESS

*THE PHOTOCATALYTIC PROCESS IS PRECEEDED BY A CARBON DIOXIDE CAPTURE FROM AIR OR FLUE GAS STREAMS.

*A STATIONARY BED PHOTOREACTOR CONTAINING THE AEROGEL PHOTOCATALYSTS MAY BE USED FOR BOTH CAPTURE AND PHOTOCATALYSIS WITH SEQUENTIAL/ INTERMITTENT TIME-CONTROLLED SWITCHING MECHANISM.

*ALTERNATIVELY, CARBON DIOXIDE CAPTURE/ ADSORPTION REACTOR IS SEPARATE FROM THE PHOTOCATALYSIS REACTOR, USING A MOVING-BED TECHNOLOGY TO TRANSFER THE CO2-LADEN AEROGEL PHOTOCATALYSTS FROM ADSORPTION REACTOR TO PHOTOCATALYSIS REACTOR.

*ENGINEERED DESIGNS MAY BE USED ON LARGE, MEDIUM, OR SMALL SCALE [HOUSE HOLD VERSIONS].

STATIONARY BED PHOTOREACTOR USING SOLAR DAYLIGHT ONLY

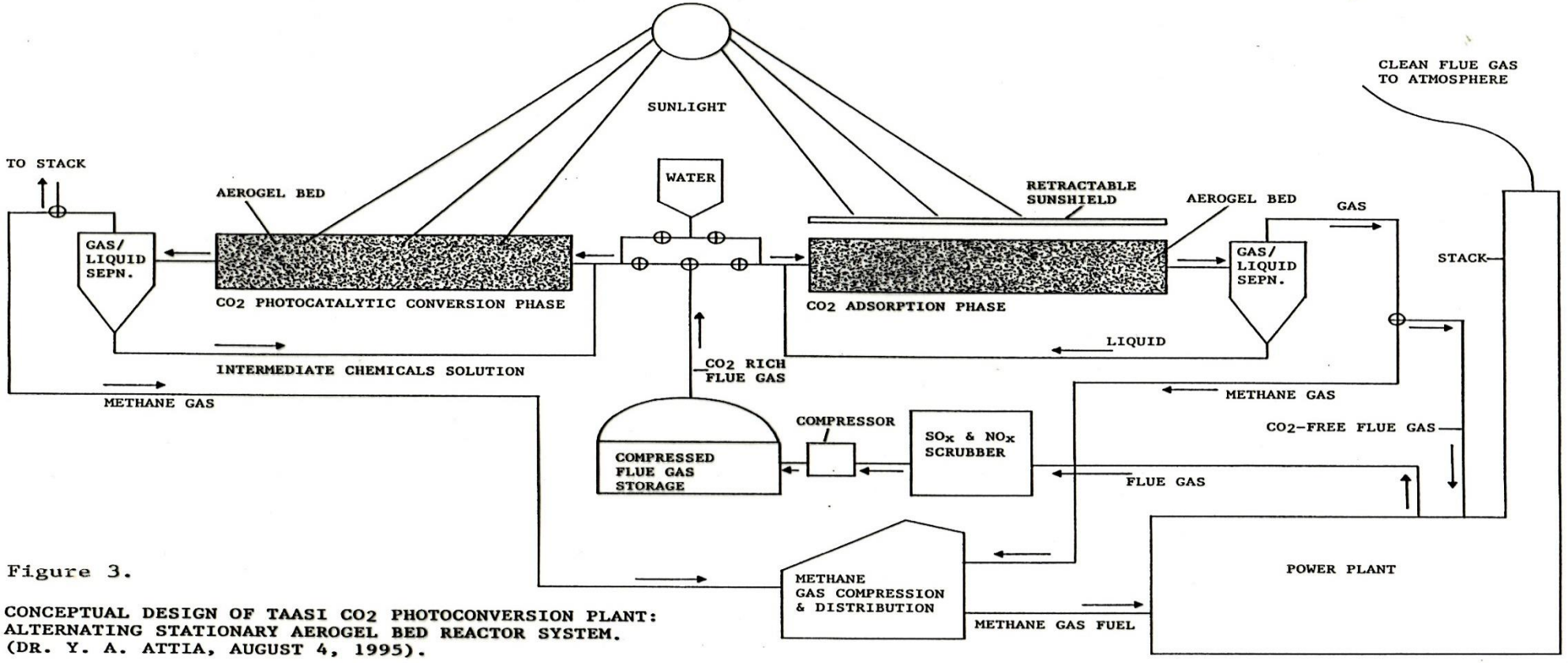
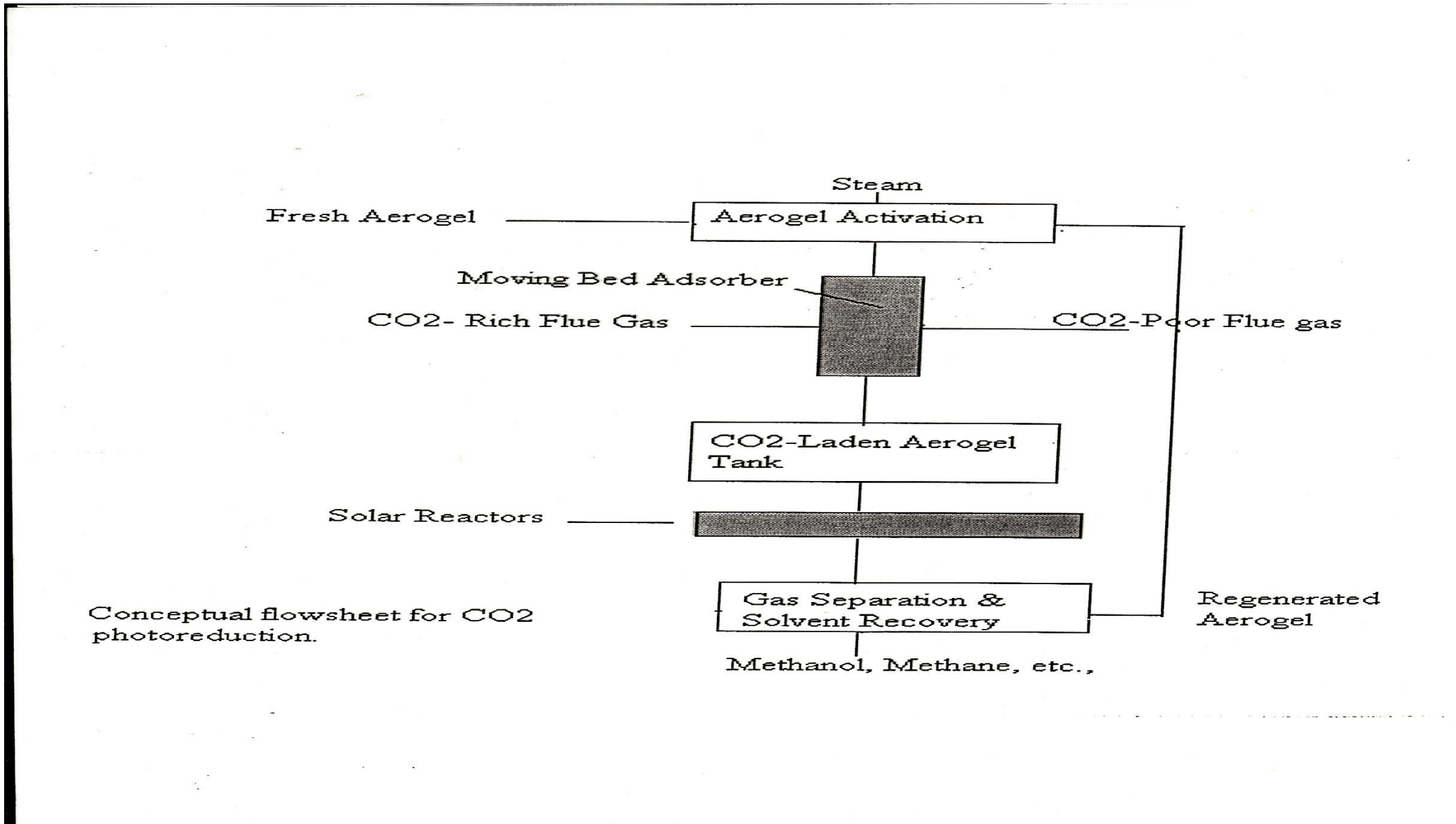


Figure 3.

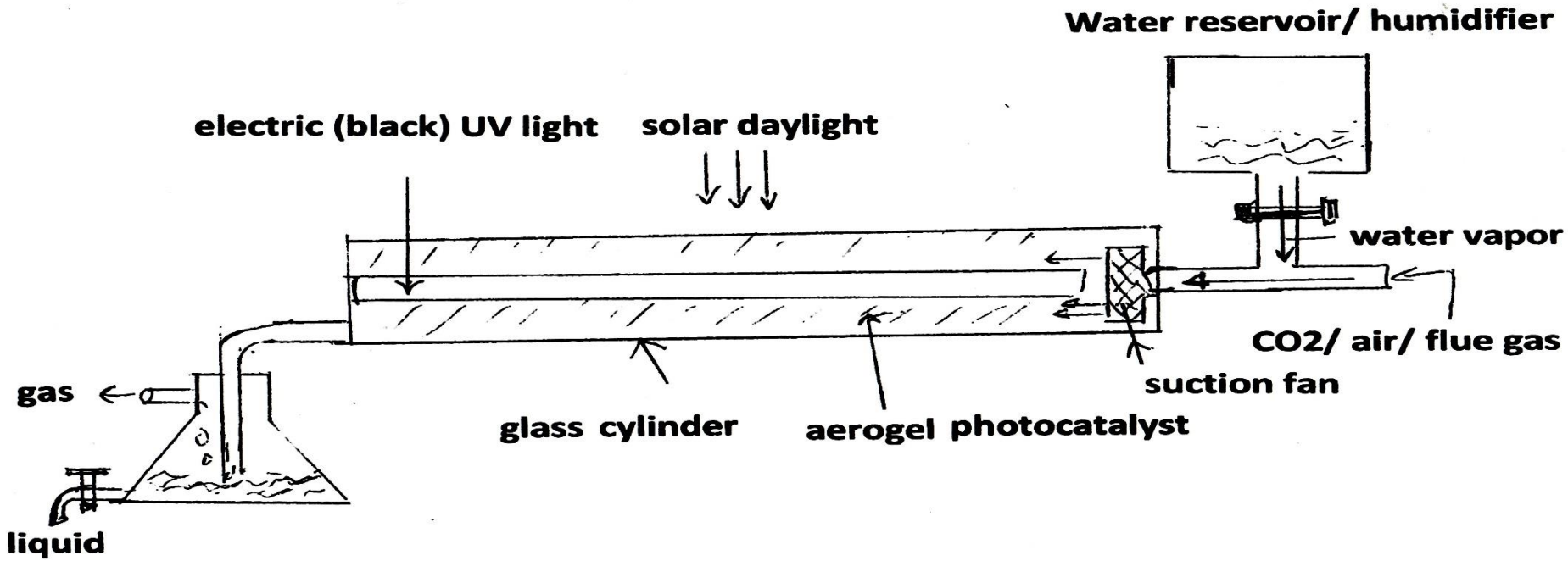
CONCEPTUAL DESIGN OF TAASI CO_2 PHOTOCONVERSION PLANT:
ALTERNATING STATIONARY AEROGEL BED REACTOR SYSTEM.
(DR. Y. A. ATTIA, AUGUST 4, 1995).

MOVING BED SYSTEM WITH SEPARATE REACTORS FOR CO2 CAPTURE AND PHOTOCATALYSIS USING SOLAR DAYLIGHT ONLY

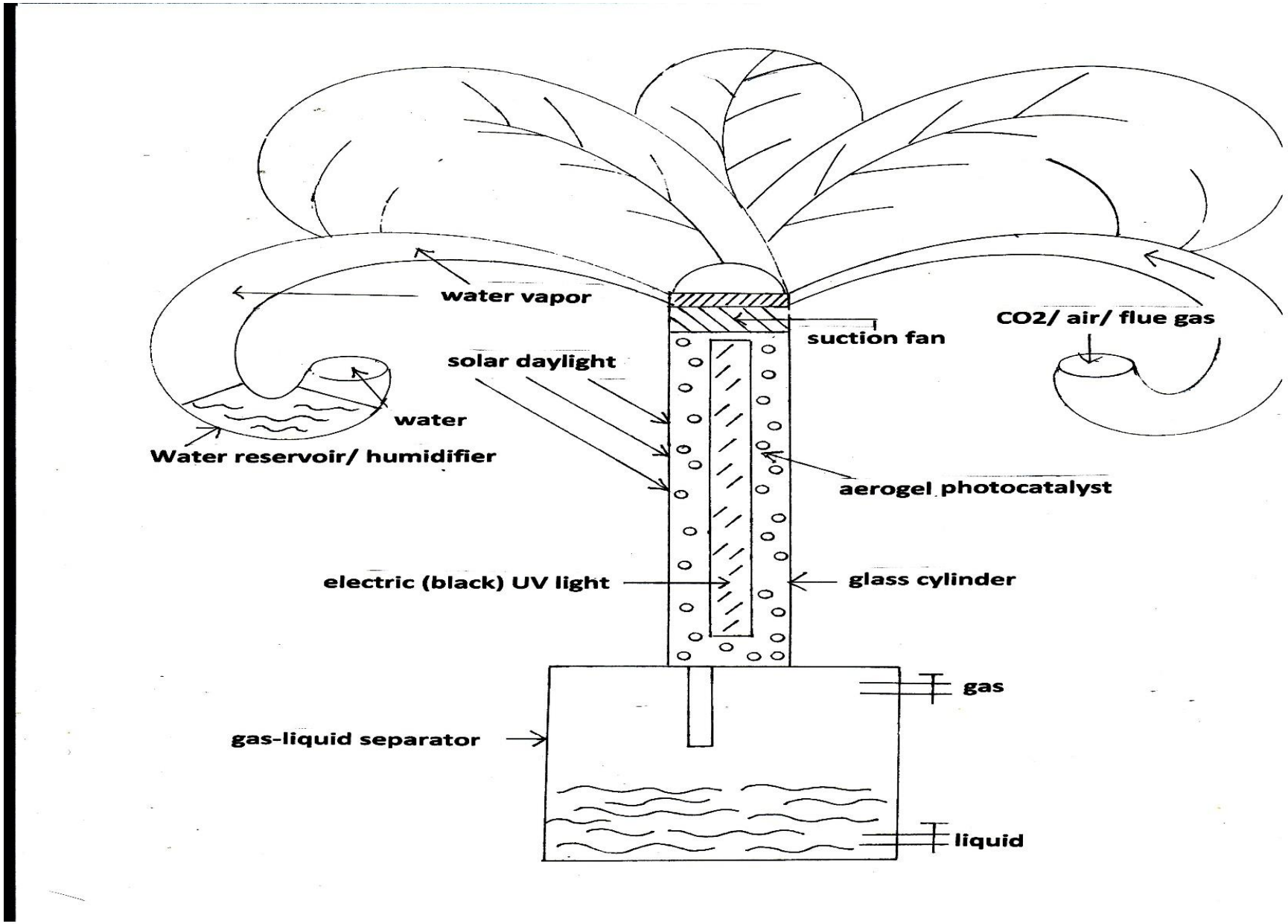


Conceptual flowsheet for CO2 photoreduction.

STATIONARY BED PHOTOREACTOR USING BOTH DAYLIGHT AND ELECTRIC LIGHT



THE "AEROGEL PHOTOCATALYST TREE" USING BOTH DAYLIGHT AND ELECTRIC LIGHT [preliminary design]



CONCLUSIONS

THIS ENGINEERED PHOTOSYNTHESIS TECHNOLOGY SHOULD BE FULLY DEVELOPED FOR THE FOLLOWING POTENTIAL BENEFITS:

- **IMPLEMENTATION COST IS EXPECTED TO BE OFFSET BY SALE OF CHEMICALS OR FUELS PRODUCED**
- **WIDE SCALE APPLICABILITY TO POWER PLANTS AND INDUSTRIAL MANUFACTURING FACILITIES AS WELL AS COMMERCIAL AND RESIDENTIAL**
- **SIGNIFICANT REDUCTION OF CARBON DIOXIDE EMISSIONS WITH FAVORABLE IMPACT ON THE GLOBAL WARMING SITUATION**
- **EFFICENT PROCESS AND REACTOR DESIGN USING GAS/ VAPOR REACTION MEDIA, AS WELL AS HIGHLY EFFICIENT AEROGEL PHOTOCATALYSTS**